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Volume 2 of 3

REPORT TO THE CONGRESS
Department of Energy Organization Act

Title X

SUNSET REVIEW

PROGRAM-by-PROGRAM ANALYSIS

U.S. Department of Energy
Office of Policy, Planning and Analysis

February 1982

DOE/PE-0040 (Vol. 2)
Volume 2 of 3

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SUNSET REVIEW

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U.S. Department of Energy
Office of Policy, Planning and Analysis
Washington DC 20585

February 1982

Preface

This Program-by-Program Analysis is a supplement to the President's Summary Report to the Congress in satisfaction of requirements of Title X ("Sunset Provisions") of the Department of Energy Organization Act of 1977 (P.L. 95-91).

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INTRODUCTION

INTRODUCTION

The House and Senate bills passed to create a Department of Energy differed in that the "Sunset provision" of the House bill would have required, after a period of 5 years, that Congress take specific action to keep the Department in existence. Without such action, the Department of Energy would terminate automatically. The Senate bill did not contain such a provision. The Conference Committee that considered the two bills agreed on a compromise requirement for a "Sunset" review of all the Department's programs. This compromise requirement was included in Title X of the Department of Energy Organization Act of 1977 (P.L. 95-91). The Summary Report to the Congress, which is being submitted by the President, and this Program-by-Program Analysis together satisfy the "Sunset" review requirement of Title X.

Conduct of the Review

Title X of the Department of Energy Organization Act specifies 14 points to be addressed in the "Sunset" review. Of these, five--see 42 USC 7352, section 1002 (2), (6), (7), (12), and (13)--are critical to the design of the review; they have shaped the President's Report, as well as the Program-by-Program Analysis and its Appendix. Three of these points are retrospective, requiring identification of historical goals and objectives for the Department's "program,"* assessment of the degree to which each objective was achieved, and a statement of program accomplishments. The other two critical points are prospective, requiring identification of current objectives and an assessment of resources required to achieve these objectives. The remainder of the 14 points are ancillary to these 5, with varying degrees of applicability to the review of specific programs.

This Program-by-Program Analysis describes past accomplishments, shows the transition from historical programs to current directions, and addresses anticipated needs. Because the Nation's energy situation and energy

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*The term "program" was not defined in the legislation. For review purposes, DOE programs and resources were divided into 59 program analysis units (PAU's) which were aggregations of more detailed budget groupings.

policies have changed appreciably since the Department was formed, great care has been taken to ensure that the performance of the Department is measured in the context of program objectives as they existed during the previous 4 completed fiscal years, as specified in Title X. Efforts also have been made to show the evolution of objectives over the life of the Department.

Historical Context

The past decade has been one of rapid evolution both in our understanding of the Nation's energy problems and in the development of national policies and programs to deal with these problems. Before 1972, energy supplies were ample and energy prices, in real terms, had been declining for years. Federal energy policy was relatively narrow in scope and was directed toward maintaining stability in energy markets. Federal expenditures focused on relatively limited support of long-term research and development, a traditional Federal role.

Underlying trends, however, were less favorable; and their effects began to be felt by the late 1960's. Excess production capacity in the domestic oil industry disappeared, with oil production peaking in 1970. Production of domestic natural gas peaked in 1971. An expanding economy increased demand for energy supplies. At the same time, a growing concern for environmental quality was reflected in a variety of legislative and regulatory measures that focused demand growth on oil and natural gas (while domestic production of these fuels was declining) at the expense of the Nation's supplies of coal and nuclear power.

One result of this pattern was the rapid increase in U.S. dependence on foreign oil imports in the early 1970's. Concurrently, the market power and cohesion of the Organization of Petroleum Exporting Countries (OPEC) were increasing.

World oil prices were beginning to rise, but not yet enough to distress most final consumers or to cause the Nation's policy-makers to increase attention to this critical aspect of economic policy. The Arab oil embargo that occurred in 1973 resulted in a fourfold increase in world oil prices; a flurry of policy-making and legislative activity, aimed principally at solving short-term problems, quickly followed. Oil price controls, already in place under the Economic Stabilization Program, were extended. Since prices were controlled and could not be used to bring supply and demand into balance, demand exceeded supply. Refiners with limited access to price-controlled domestic crude oil complained that they could not sell products that were derived from higher priced imported oil, and allocation controls were considered necessary to determine priorities for the distribution of underpriced supplies. A complex system of "entitlements" to share the benefits of lower priced domestic crude oil was imposed.

As the visible impacts of the embargo waned, concern for the longer term took the form of a drive for "energy independence." The premise was that the United States would not be hurt by future oil supply disruptions if it reduced imports; the more successful our efforts to reduce imports, the less susceptible we would be to the impacts of future disruptions. This approach led to intensive policy efforts to develop alternative energy sources. But the cost of conventional fuels was again declining in real terms, leaving the private sector little incentive to fund development of high-risk, high-cost alternative technologies. Thus, the Federal Government doubled and redoubled its energy research and development budgets. Research and development programs were expanded to encompass demonstration and commercialization activities under the presumption that if the Government could demonstrate the effectiveness and reduce the costs of selected new technologies, industry would adopt them.

This acceleration of research, development, and demonstration on a broad range of energy technologies did not achieve the desired results for several reasons. Initially, a "shotgun" approach was used in the selection process, and there was a tendency to fund almost all lines of research that showed any degree of promise in the early stages of research and development. As these projects matured and reached the costlier research and development stages, they acquired individual constituencies, and it became difficult to reach a consensus as to the most promising approaches and to cancel other competing, but less promising, projects. Since the Federal Government was funding the research, market tests did not play the key role they should have in selecting candidates for advanced development; and the Government found itself pumping billions of dollars into technologies that were not as cost effective as others being pursued.

In summary, the turbulent decade of the 1970's was a period of explosive growth in Federal activity in energy matters. The primary conclusion drawn from this experience was to relearn the lessons of the marketplace: that regulatory intervention in markets is more likely to further disrupt them than to correct perceived imperfections; such intervention does not bring about the desired long-term adjustments; and the market is much better at selecting energy sources and technologies for development than is the Federal Government.

Current Policy

The market orientation of the Reagan Administration is the result of the experience gained and the lessons learned, and relearned, in the 1970's. The Administration's approach to energy, outlined in the National Energy Policy Plan of July 1981, is part of an overall economic policy that calls for less Federal intervention across the board, including less spending, less regulation, and less taxation. Current energy policy acknowledges the central role of the private sector in decisions about energy production and consumption and accepts appropriate limitations on the Government's role.

Results of the Review

The Sunset Review of the Department of Energy was designed to examine past and current objectives of the Department and the programs designed to achieve those objectives. The conduct of the review has been valuable in what it has revealed about the Department's programs, both in the way the programs fit into energy policies past and present, and in how well the programs performed in meeting their objectives. These programs were guided by the intent of enabling legislation, and many programs were successful in achieving the objectives set for them.

Whether the historical objectives and activities of many departmental programs represented the best allocation of resources or an appropriate role for the Federal Government is another question. In the context of current policy, many of the Department's programs have been found to be outside the Federal role in the energy sector of the economy. For these programs, the Administration has proposed no new funding. In other cases, the Administration has proposed reduced levels of funding in line with its policy to reduce Federal spending and exercise fiscal restraint. The program-by-program analysis that follows describes projected program activity in light of the Administration's energy and economic policy.

Dismantlement

In view of the demonstrated success of energy markets in those instances when they have been allowed to function freely, and understanding the limited role and responsibilities of the Federal Government in this sector of the economy, it is no longer necessary or appropriate to maintain a Cabinet-level Department of Energy. The Department was established to address a set of problems that would have resolved themselves more quickly and more effectively without Government intervention in energy markets in the first place. The Federal budget has been revised to reflect the Reagan Administration's policies. The remaining functions that necessitate a Federal role can be managed more effectively within other established elements of the executive branch, principally the Departments of Commerce and the Interior. Legislative proposals to effect the dismantlement of the Department of Energy are being submitted to Congress by the President to reflect changes in the Nation's energy situation and the organizational structure that is appropriate to the reduced Federal role described above.

Scope of the Program-by-Program Analysis

The program-by-program analysis contained in this document follows the structure and organization of the President's Summary Report, and provides supplementary detail in satisfaction of Title X of the Department of Energy Organization Act of 1977. It consists of two parts: overview sections and individual narrative evaluations for 59 program analysis units (PAU's); and an appendix that provides funding and program information in tabular form for each PAU, along with the funding control table for the Sunset Report.

As indicated in the President's Summary Report, the 14 specific Sunset review requirements of the Department of Energy Organization Act do not apply equally to all programs and activities covered by this report. Therefore, for the benefit of the reader, the contents of Volume II are described below in terms of each of the 14 specific points of the act.

Overviews

Each overview provides general information about the program analysis units contained in that particular section of the report, and responds in general terms, where results of individual programs cannot be precisely measured, to the requirements of Title X, with particular attention to section 1002 (8), numbers and types of beneficiaries; section 1002 (9), economic impacts; and section 1002 (10), health and safety impacts.

Narrative

The title of each narrative is followed by an abbreviation (listed on p. xiv) which responds to the requirements of section 1002 (1). The narrative itself is subdivided into four sections. The Program Objectives section responds to section 1002 (2), (3), and (4). The Program Results section responds to section 1002 (6), (7), and (11), and--where applicable--to (8), (9), and (10). Projected Program Requirements contains information related to section 1002 (5), (12), and (13). The section on Transitional Requirements responds to section 1002 (14).

Appendix Tables

For each program analysis unit, Table 1 provides additional details about goals, objectives, accomplishments, and budgets for the fiscal year 1978 through fiscal year 1981 period. Table 2 provides additional details on current and projected goals, anticipated needs and budget justification for fiscal year 1982 and beyond for all PAU's, except those for which no funding was provided in fiscal year 1982 or earlier.

Funding Data

All historical and fiscal year 1982 funding data in the narratives and tables are current as of December 18, 1981. A description of the method used to develop funding data is provided in the Appendix.

It should be noted that a somewhat different structure is used in the President's fiscal year 1983 budget than is used in this report. Therefore, there will be minor discrepancies in a few cases between fiscal year 1982 amounts in this volume and amounts shown for fiscal year 1982 in the President's fiscal year 1983 budget. Budget data for fiscal year 1983 is not contained in this document; it may be obtained from the President's budget for fiscal year 1983, as presented to Congress.

The following abbreviations are used after the title of each program analysis unit to identify the Department element responsible for the program:

CE	Assistant Secretary for Conservation and Renewable Energy
DP	Assistant Secretary for Defense Programs
EI	Administrator, Energy Information Administration
EP	Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness
ER	Director of Energy Research
FC	Chairman, Federal Energy Regulatory Commission
FE	Assistant Secretary for Fossil Energy
HG	Director of Hearings and Appeals
IA	Assistant Secretary for International Affairs
MA	Assistant Secretary for Management and Administration
NE	Assistant Secretary for Nuclear Energy
RG	Administrator, Economic Regulatory Administration

A.

REVIEW OF ENERGY RESEARCH, DEVELOPMENT, AND APPLICATION PROGRAMS

1. Energy Supply

a. Fossil Energy

<u>OVERVIEW</u> Fossil fuels--coal, oil, and natural gas--accounted for 90 percent of the energy consumed in the United States during 1980. According to projections made for the National Energy Policy Plan,* fossil fuels could still be supplying 80 percent of all U.S. energy in the year 2000, and perhaps 70 percent in the year 2020. For this reason, the fossil fuel programs are a logical starting point for an analysis of Federal research and development in energy.

As conventional supplies of domestic oil and gas are depleted, it will take increasing amounts of unconventional gas and oil (that is, oil and gas not recoverable by the methods in common practice), and of synthetic fuels produced from the massive U.S. coal and shale resources, to meet our national demand. For example, the National Energy Policy Plan projects that 20 percent of our fossil energy supply in the year 2000 will consist of gaseous and liquid fuels from sources other than conventional production; and this percentage is projected to rise significantly after that. Much of this supplemental production will have to come from technology that is just being introduced or is still under development. Similarly, the future production of electricity and process heat is expected to rely heavily on advanced coal combustion technology that is more efficient and environmentally benign than the technology in general use today.

The rate at which such new fossil energy technologies enter the marketplace will depend on a variety of interrelated factors, including overall energy costs, local air quality standards, regional water availability, basic socioeconomics, and other factors. Advanced technology can have a favorable impact in all these areas. For example, a new, high-efficiency

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*U.S., Department of Energy, Office of Policy, Planning, and Analysis, <u>Energy Projections to the Year 2000</u>, A Supplement to the National Energy Policy Plan (Washington, D.C.: Government Printing Office, 1981). DOE/PE-0029.

process not only may produce energy less expensively than an older, less efficient process, but also, if emissions remain the same for both, would result in fewer emissions per unit of energy produced.

Projections such as those cited above are better appreciated when one examines the fossil energy resource base and the costs associated with using different fuels. Conventional oil and gas account for more than 70 percent of current domestic energy consumption. Oil and gas reserves and undiscovered potential are estimated to be between 24 and 37 times current annual oil and gas consumption. While it therefore is likely that conventional oil and gas supplies will last into the next century, much of the undiscovered portion will be expensive to recover since it is located in hostile environments. Furthermore, current depletion rates plus limitations on how fast new reservoirs (especially ones in hostile environments) can be brought into production and produced suggest that conventional domestic oil and gas supply is likely to start declining significantly in the 1990's.

Unconventional oil and gas will be more expensive than most current conventional production, probably roughly competitive with much of the undiscovered resources in hostile environments, and most likely less expensive than synthetic fuels from oil shale and coal, particularly coal.

The recoverable resource of unconventional oil and gas is estimated to be between 4 and 16 times current domestic annual consumption of liquid and gaseous fuels--with the larger amount predicated on the success of high-risk research and development. Even this is a relatively small fraction of the total unconventional resource, and it is possible that a larger portion can be recovered using technology not currently envisioned. Thus, the unconventional oil and gas resources can be an important source of fuel for supplementing dwindling conventional production in the 1990's, especially before large-scale synthetic fuel production can be achieved.

U.S. coal and oil shale resources are large enough to be considered almost unlimited for most planning purposes. For example, the estimated recoverable coal resource is roughly 300 times current annual oil and production, and the domestic oil shale resource is about half this size. However, some further technological advances are required to convert resource <u>potential</u> into resources that are technically and economically <u>recoverable</u> (and capable of being developed in an environmentally acceptable manner). If a high-risk, high-payoff research and development program could succeed in making an incremental 10 percent of the potential fossil energy resource (including oil and gas resources) recoverable, this would be almost like duplicating the total proved oil reserves of the Persian Gulf. Such a "modest" unconventional increment would quadruple the proved reserves of oil and gas in the United States today.

The problems of tapping plentiful resources of fossil fuels in this country are more complex than one might assume--partly because a commonly used term such as "coal" actually covers a challenging assortment of material mixtures. Coal types range from lignite to anthracite, differing substantially in heat content as well as in accessibility. Some have a greater tendency than others to cake. There is great variety in carbon content and reactivity, as well as in the amounts of associated volatile matter, sulfur and ash. Whether coal is to be burned directly or processed into a liqu or gaseous fuel-form, each of these characteristics may become a factor of great consequence.

While the Nation is fortunate to have abundant fossil energy resources, we will need diverse and extensive advances in the scientific and engineering knowledge base to use these resources effectively. Systematic technological advances must occur at all stages of the research, development, and commercialization cycle--from basic science to applied research, to proof-of-concept, then process development, and finally to the stage of commercialization. The latter stages of this cycle are the most costly, and this is where extensive private sector investments will be required to take advanced technologies into commercial reality. The earlier stages (through proof-of-concept) feed this research-and-development investment pipeline through the results of longer term, high-risk, and potentially high-payoff research. In these earlier stages, however, payoffs are frequently difficult to predict, highly risky, or far down the road. At times, there may even be benefits that cannot be captured by individual firms.

It is in these areas that front-end Federal support, sometimes in cooperation with industry support, can contribute to establishing an adequate scientific and engineering knowledge base for technological advances through private sector initiative in the latter stages of the cycle. The benefit/cost ratio of a Government-sponsored basic and applied research program in cooperation with industry is potentially very high.

For purposes of the Title X review, the Department of Energy's fossil energy program has been divided into the 16 program analysis units (PAU's) that follow this overview. Both historical (fiscal year 1978 through fiscal year 1981) and current (fiscal year 1982 and beyond) goals and objectives are listed for each program, providing the basis for an evaluation of each program's past performance and an estimate of projected program requirements. To view all of this in context, it should be kept in mind that the current fossil energy program and its specific program goals are based on a single overall goal and several strategic objectives.

The overall goal is to develop the scientific and engineering knowledge base with which industry can bring economically competitive and environmentally acceptable new fossil energy resources and technologies into the marketplace.

Consistent with the Department of Energy's basic priorities, this particular goal addresses activities that are critical to improving the understanding of fundamental scientific and engineering mechanisms and to predicting the performance of new energy resources and advanced technologies. In addition to process-related research and development, the fossil energy program will continue to support programs of basic and applied science for coal, oil shale, oil and gas, and other generic or crosscutting basic and applied sciences that are closely related. A strong basic and applied research effort is essential to increasing our understanding of the fossil energy resources and our ability to effectively assess the different ways they can be used.

Federal programs will focus on elements that attract limited or no private venture capital. Federal research and development will be in potentially high-payoff areas where the risks are too large or unpredictable and the payoffs are too far down the road or too uncertain, or cannot be captured by individual firms. Within these areas, Department efforts will aim at advancing the level of development to the point where sufficient data are available for the private sector to conduct its normal technical, economic, and environmental risk assessments and for private investors to determine the time of the technology's introduction into the supply mix. Private sector participation will be sought in individual projects, both to increase the impact of Government expenditures and to focus Government efforts toward activities the private sector ultimately will support totally.

Emphasis will be placed on technologies that contribute to conservation (that is, major generic improvements in the efficiency of energy use), as well as on technologies that can help the United States shift from using the relatively scarce conventional oil resources to using more abundant fossil resources (such as coal and oil shale) in an environmentally acceptable manner.

In aiming for its overall goal, the fossil energy research and development program has set several strategic subgoals. The highest priority strategic subgoal is to develop the scientific and engineering knowledge base required by the private sector to directly reduce U.S. vulnerability to the economic and security implications of reliance upon relatively scarce and increasingly expensive conventional oil resources. Reliance on imported sources of oil and on our own inherently finite conventional oil resources can be lessened through the development of supply technologies that provide new ways of satisfying the specific demand for liquid fuels--including technologies that allow coal to displace oil in one way or another.

Principal requirements in meeting this subgoal include the following:

- Establishing the data bases to enable industry, with the assistance of the Synthetic Fuels Corporation where necessary, to develop as rapidly as possible significant, economically competitive, new liquid supplies with acceptable environmental impacts. This is essential if nonsubstitutable uses for liquid fuels (particularly transportation fuels) are to be sustained without increasing the overall cost of liquid energy supplies. Major emphasis must be given to mitigating those technical and economic constraints and environmental concerns that result in perceptions of technical risk or lack of economic competitiveness that especially deter private-sector investments in commercial production.

- Extending the scientific and engineering knowledge base required for the development of advanced systems that can speed up the substitution of coal for oil in utility and industrial applications where conventional coal-firing technology is now effectively precluded. Particular attention will go to mitigating those technical, siting, materials handling, waste disposal, or other environmental constraints that prevent the large inventory of oil-designed equipment in place from being retrofitted economically for coal-firing, and that discourage some new installations from burning coal rather than oil.

To achieve the first strategic subgoal via these routes, developmental activities of the Department of Energy are still seeking to accomplish the following:

- o To establish, through a program of exploratory research and development, the scientific and engineering basis for improved or advanced processes for enhanced oil recovery, processing, and use of currently inaccessible petroleum resources

- o To establish the data base required to develop more efficient and environmentally benign processes for recovery of leaner oil shale resources, and to overcome potential technical and environmental constraints that could limit the scale of a shale oil industry in the longer term

- o To establish a technical and environmental knowledge base in direct and indirect coal liquefaction (including those aspects of gasification critical for indirect liquefaction) that will be adequate for the move to major new technology that can compete economically with other liquid fuels in the longer term

- o To develop new approaches for coal preparation, combustion, and control technologies for substitute fuels at existing and new installations designed to burn oil

The second high-priority fossil energy strategic subgoal is to develop scientific and engineering knowledge that can contribute significantly toward ensuring the adequacy of longer term, economical, and environmentally acceptable supplies of gaseous fuels to supplement conventional sources. Establishing a foundation of technical understanding upon which the Nation can build a diversity of new domestic sources of gas can help "cap" gas prices well below the expected prices for oil and increase public confidence in the reliability of future gas supplies at competitive prices.

Apart from the Department of Energy's programmatic activities, a concerted national effort is under way to use other instruments of policy to remove artificial demand constraints on gas, to stimulate increased supplies of gas, and to make supply more reliable while supply markets become more competitive. While all of these non-research-and-development measures should make gas markets more economically efficient for the near term to midterm, the research and development goal within the Department complements them in the midterm to longer term.

U.S. efforts to displace oil with gaseous fuels are still being deterred by uncertainties about both the longer term quantity and the full costs of domestic supplemental gases. Reducing these uncertainties is critical to many Americans. It will help Federal, state, and local officials make better decisions about regulatory policies affecting gas supply and gas demand. It will guide consumers in making longer range commitments to the use of gas. And, it will enable suppliers to establish a supply market at prices that can sustain gas demand (in preference to liquids) yet can also ensure ample supplies.

The major tasks for the Department of Energy in regard to gas technologies are now these:

- To establish the technological basis for new sources of low-, medium-, and pipeline-quality gaseous fuels for industrial and electric utility use, as well as for petrochemical feedstocks. (All these demands are potential "swing sectors," in which significant substitution for oil might be made in both existing and new installations.)

- To develop new, more efficient technologies for <u>using</u> gas, because these may be important in keeping gas economically competitive as gas prices rise as a result of decontrol.

In carrying out the tasks, there are certain areas in which Federal research and development efforts are now seen as potentially most fruitful:

- More basic knowledge (both about technique and about environmental impact) is needed to encourage significant improvements in developing practical and acceptable coal gasification systems with a medium-Btu product, which could be used directly as fuel for industrial applications and electric generation or as an intermediate feedstock in industrial chemical processes and in the production of substitute natural gas.

- A full-fledged scientific and engineering data base remains to be developed for certain advanced energy systems (such as fuel cells), which have high potential payoffs in efficiency, environmental performance, and oil displacement.

The third high-priority subgoal is to establish the scientific and engineering foundations for the greatly increased use of coal and other abundant fossil energy resources through improved technologies with high payoffs in potential economic improvements, improved efficiency and flexibility of coal use, and improved environmental performance. In this case, there are two areas of technology development in which major contributions can be made by Federal research and development:

- A firmer technological basis is needed for various technologies that appear to promise improved economics, efficiency, and environmental performance in using coal directly. This group includes the technologies of combustion systems, coal-using fuel cells, and environmental controls.

- Coal mining technology that addresses the longer range concerns for increased mining productivity may have a limited market at present but will become increasingly important to coal supply as more marginal coal resources are tapped.

Overall, the fossil energy research and development program has not duplicated private-sector activities in the past; and no significant overlap is expected in the future. There will be some changes in the way efforts are divided, however. In the recent past, cost-sharing projects included some pilot plants and large demonstrations. The economic policies of the current Administration are expected to provide the necessary incentives for the private sector to support demonstration activities, so the Federal fossil energy program has been reoriented to focus on the earlier stages of research and development (through proof-of-concept). These earlier stages might otherwise continue to be underfunded by industry (in relation to their potential contribution to the Nation's economic welfare) because of uncertainty about returns on investment. Cost-sharing with industry will continue, albeit with this change of focus within the research and development cycle, because industry's involvement is expected to help concentrate efforts on areas that are likely to be adopted for full industry support. Furthermore, industrial association with the various projects is likely to facilitate technology transfer in cases where it can be useful. Thus, the Federal program will continue to complement private efforts rather than duplicate them.

Although several fossil energy programs seek to serve the same general market, there is no duplication there either. For example, coal liquefaction, enhanced oil recovery, and shale oil development all are intended to supply liquid fuels; but it is unlikely that any one of these will be adequate by itself. First of all, the projected national supply problem is quite large. Second, the liquid products that can be drawn most easily from coal and oil shale are not identical with the full range that comes from natural petroleum; and different end-uses need to be satisfied. The liquid fuels produced most efficiently from coal are gasoline and distillate fuel oil. From shale oil, the most reasonable products are diesel and jet fuels.

The technology development supported by the fossil energy program is oriented toward national markets, so nearly all energy consumers benefit when any one of them achieves even partial success. This is particularly true for technologies contributing liquid and gaseous fuels, since pipeline delivery is feasible and relatively cheap. Technologies oriented toward production of electricity also have a national market, although specific utilities may not choose to use all of them because of their unique circumstances. All technologies supported by the fossil energy program will meet existing environmental health and safety standards; and in some cases standards will be exceeded significantly.

Four years after the establishment of the Department of Energy, it is natural that various elements of the fossil energy research and development program have matured at different rates and achieved different stages--as reflected in detail in the PAU's. Two of the program analysis units in this section cover activities that no longer are essentially relevant to the departmental mission and thus were discontinued during fiscal year 1981. The phaseout of four more programs during fiscal year 1982 has been proposed. Additionally, the functions of one program have been transferred to the Department of the Interior, and another program is expected to be transferred to the Department of Commerce.

The following two programs have been discontinued:

- o Alternative Fuels--This program to stimulate commercial synthetic fuels development is now the responsibility of the Synthetic Fuels Corporation. The Department of Energy has completed all activities associated with its awarding of funds in this regard appropriated under the Alternative Fuels Production Act of 1979 (P.L. 96-126) and the Energy Security Act of 1980 (P.L. 96-294); but it is continuing to monitor ongoing studies and the projects that received awards.

- o Domestic Energy--This program aimed at increasing the availability of fuel supplies utilizing coal, shale oil, and gas resources through direct Federal involvement in a variety of projects that at the time were considered fairly novel within the industry. Although changing circumstances (both in energy prices and the availability of technical experience) have led to a cessation of this activity for the most part, some Federal information-gathering oriented toward policy issues is expected to continue.

The four research and development programs for which phaseout during this fiscal year is proposed are the following:

- o Magnetohydrodynamics (MHD)--Although MHD is one of several advanced fossil energy technologies that offer significant long-term potential for increasing efficiency and improving the environmental performance of coal-fired powerplants, the potential costs to complete its development now appear very high. Thus the Administration has proposed to phase out the program in fiscal year 1982, and no funding has been requested in fiscal year 1983. Program discontinuation will require payment of contract termination costs, cancellation of several international agreements, and disposition of equipment and facilities.

- o In Situ Coal Gasification--This technology is also projected to have a positive impact eventually if it should prove successful; but, its priority is not as high as others in the current period of budget reductions and fiscal constraints. The fiscal year 1982 budget of $8.3 million will allow assessment and in-situ field testing to be completed at the steeply dipping subbituminous coalbeds near Rawlins, Wyoming; and several other technology-base activities will also reach a point where the data can be transferred effectively to industry. The fiscal year 1983 budget request is a termination of program activities, providing only for postburn environmental monitoring required by law. Program requirements through fiscal year 1987 provide only for environmental monitoring of the site.

- o Heat Engines--In conjunction with the refocusing of the coal research and development program, it is proposed that this program move toward an orderly termination during fiscal year 1982. While this technology is projected to have significant potential for positive impacts, activities have matured to the point where the private sector can continue further development of the technologies.

- Unconventional Gas Recovery--Unconventional sources of gas, particularly tight gas sands, are projected to have a significant positive impact. Since there appears to be increased industrial activity in this area, however, it is proposed that a diminishing Federal role is appropriate. The program has demonstrated that coalbed methane can be produced and used both with and without associated mining operations. Resource evaluation for eastern Devonian shales is essentially completed, and final verification of the results is expected to be done by industry. Industry is also beginning to develop the least difficult western tight blanket sands.

Some other major components of the fossil energy programs were discontinued in the process of narrowing their focus to longer term, high-risk, potentially high-payoff research and development. In general, these involved large-scale hardware testing. More details can be found in the individual PAU's.

The Department of Energy Federal Leasing Program, established to develop Federal leasing policies for all federally owned and administered energy mineral resources, was transferred to the Department of the Interior at the end of 1981. The Mining Research and Development Program has developed various aspects of technology to improve the productivity of coal extraction to a point where acceptance by industry for commercialization is under way. Remaining efforts have been reoriented from heavy emphasis on outside contractual efforts to an in-house research program that can be consolidated easily with activities at the Department of Commerce.

These and other fossil energy programs are treated in greater detail in the following program analysis units.

(1) COAL MINING RESEARCH AND DEVELOPMENT* (FE)

Program Objectives

The Mining Research and Development Program within the Department of Energy was initiated to stimulate the development of more efficient and acceptable technology for coal production. The Department's program has focused on technological development for both surface and underground mining. The Department has used in-house researchers, universities, consultants, mining equipment manufacturers, and coal mining companies (under research contracts) to execute a coherent and coordinated program of work.

Recognized U.S. coal reserves lie at depths generally less than 1,000 feet deep and in seams more than 28 inches thick. Approximately 475 billion tons are considered mineable by state-of-the-art technology; and of this amount more than 250 billion tons are judged economically recoverable at this time. The bulk of both the economically recoverable reserves and the broader resource base within the United States is classified as "underground mineable," but only about 40 percent of current coal production comes from underground mines while 60 percent is being taken from surface sites.

A major determinant of expanded use of U.S. coal is economics. Most U.S. coal is sold on a long-term, cost-plus contract basis, indexed to a variety of cost escalators. Coal mining productivity fell sharply during the 1970's, resulting in steady pressure for increased coal prices. This adds to other disincentives, such as the adverse environmental impact feared from increased coal use. Labor productivity is a critical element in coal cost, and improved technology may well be a key to increased productivity. The thrust of the Department of Energy's program in coal mining research and development has been to improve productivity through the development of new mining equipment and systems that can be used in a wide variety of physical environments.

The Mining Research and Development Program for which the Department is currently the custodian dates back to an authorization by the Bureau of Mines Organic Act of 1910 (P.L. 61-179, section 2). Although the Bureau engaged in modest levels of research on coal mining productivity throughout the subsequent decades, its first major technological effort was triggered in 1974 by Project Independence. Although the Energy Research and Development Administration (ERDA) was given authority at that time to

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*Coal preparation, which was part of the Mining Research and Development Program in fiscal years 1978-80, was shifted to the Advanced Environmental Control Technology Program in fiscal year 1981 and is treated in PAU #10, "Advanced Environmental Control Technology."

encourage and conduct extraction research, Congress continued to direct Federal productivity mining research funds to the Bureau of Mines' program for advancing coal mining productivity. This program was transferred to the Department of Energy upon its establishment in 1977, when the Department of Energy Organization Act (P.L. 95-91), section 302(3)(d) vested the Secretary of Energy with all Bureau functions for research and development relating to technology for increased efficiency in the production of solid mineral fuels (except for research directed to health and safety and to the environmental consequences of mining) and to coal preparation* and analysis research. Section 908 of the Surface Mining Control and Reclamation Act of 1977 (P.L. 95-87) also authorized the Department to conduct a research and demonstration program related to alternatives to surface disturbance by coal mining (including the improvement of underground mining methods, and health and safety in such applications).

The original goal of the Mining Research and Development Program within the Department of Energy was to develop and demonstrate improved technology to reduce extraction and cleaning costs for both underground and surface coal, thus improving the economic attractiveness of coal relative to other fuels. Despite budget constraints and other factors that precluded achievement of that goal in its entirety, the general intent of the effort was accomplished. The current goal of the program is a broader and longer range one--namely, to encourage the substitution of coal for oil and natural gas by supporting the development of technology and information leading to continuing reductions in the cost of underground coal extraction and major improvements in coal quality, thus enhancing the economic attractiveness of coal relative to these and other fuels. Tables 1-1 and 1-2 contain a listing of more specific objectives.

The program's past and current activities parallel and complement health, safety, and environmental research carried out by the Bureau of Mines in the Department of the Interior. The Office of Surface Mining and the Mining Safety and Health Administration, two Federal agencies with coal mining involvement, are both regulatory agencies. Their programs also are directed toward the development of methods to improve safety and the environment. However, there is often a fine line between a technology developed for health, safety, and environmental reasons or for production reasons. To be adopted, a technology generally must be both productive and safe. Hence, there are no viable alternatives to the current Federal program, except to leave all research and development to private industry.

<u>Program Results</u>

During the fiscal years 1978 to 1981 period, the Mining Research and Development Program managed more than 300 integrated contract research efforts directed toward developing, testing, and encouraging the use of innovative and improved coal mining technology. The congressionally assigned objective to investigate improved methods of mining coal has been amply executed--and with significant results.

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*See PAU #10, "Advanced Environmental Control Technology."

Among the major accomplishments were the development and trial of the first working prototypes of the next generation of room-and-pillar underground mining systems; development of a much better system for high performance training of dragline operators to overcome a major roadblock to efficient surface mining practices; the initial trials of several innovative mining systems; a number of commercial spinoffs from the program research and development efforts; the initiation of mechanisms with the safety inspectorate to speed the adoption of new technology; and a general change in the attitude of the mining industry toward the feasibility and economic practicality of technological advances.

An integral part of the Department program has always been to ensure the health and safety of coal miners and to minimize disturbances to land and water quality that result from coal extraction. A major portion of the surface mining program was directed with good results to more efficient removal and replacement of overburden to minimize the costs of meeting national regulations.

Much of U.S. industry and more than half the Nation's population depend on coal-generated electricity, so they have been direct beneficiaries of this program. The costs of coal extraction account for 40 to 60 percent of such electric power costs, and higher coal prices are routinely passed through by miner and utility to the consumer. Indirectly, the sharing in benefits is even broader because of the multiplier effect of basic energy costs on the prices of finished products and because of coal's role in helping to solve our overall national energy problem.

Earlier goals and objectives of the Federal research and development program on coal mining have been narrowed sharply as President Reagan's energy and economic policies have been implemented. Research activity on surface mining has ceased, and research and development for underground mining is now restricted entirely to supporting high-risk, high-payoff, long-term research directed to reducing the cost of coal mining. The development of actual prototype equipment will be left to private enterprise.

Some long-range milestones (such as introduction by the late 1980's of automated and integrated mining systems to replace the room-and-pillar mining equipment currently used to mine 70 percent of all underground coal) have been delayed by reduced funding under both this Administration and its predecessors, although significant system field trials were completed as planned during fiscal years 1978 through 1981. Starting 2 years ago (in fiscal year 1980), the development and testing of second- and finished-stage, prototype, room-and-pillar systems and components were postponed by reduced Federal research commitments. This made it impossible to attain the original fiscal year 1981 objective of selecting one of the several first-generation room-and-pillar system models for further development.

In summary, this program has already made substantial progress in developing improved production systems and in encouraging the adoption and trials of better techniques and newly developed components.

Projected Program Requirements

The fiscal year 1982 budget for this program is $14.2 million.

Beyond fiscal year 1982, the Administration intends to maintain the program's unique institutional base of technical skills at the Department of Energy's Mining Technology Center, and to redirect the program to in-house research activities, with the aim of developing a technological base and concepts for mining systems with high-payoff potential on a region-by-region basis.

The transfer of this program to the Department of Commerce is under consideration. Because of the program redirection beyond fiscal year 1982, it is difficult to predict what effect a change of plus or minus 10 percent in funding would have on downstream results.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(2) COAL LIQUEFACTION (FE)

To understand and evaluate the Department of Energy's activities in this field, it is necessary to know something about the two primary approaches to producing liquid fuels from coal: indirect and direct liquefaction.

In indirect liquefaction, coal is first gasified with steam and oxygen at very high temperatures (1,500° to 3,000° F) to produce a synthesis gas containing hydrogen and carbon monoxide and, depending on the gasifier used, substantial quantities of methane. After gas cleanup to remove impurities (hydrogen sulfide, ammonia, carbon dioxide), the hydrogen and carbon monoxide are reacted (using a catalyst) to produce liquid hydrocarbons.

Indirect liquefaction technology is already available commercially, and it is anticipated that an indirect liquefaction industry will be initiated in this decade through incentives provided by the Synthetic Fuels Corporation. At the present state of development, however, this technology has a relatively low thermal efficiency compared to alternatives available through advanced technologies.

In direct liquefaction, coal is slurried with a process-derived vehicle oil, and this slurry is brought into contact with hydrogen at high pressures (2,000-3,000 psi) and temperatures (800° to 850° F). In this process, coal molecules are dissolved in the oil, then hydrocracked further to produce hydrocarbons of lower molecular weight that are similar to petroleum. During this hydrocracking, atoms of sulfur, nitrogen, and oxygen are removed as hydrogen sulfide, ammonia, and water, respectively. The resulting liquid--separated from ash and unreacted coal--may be used directly as boiler fuel or upgraded further to a full spectrum of petroleum substitute fuels, such as gasoline and heating oil.

Direct liquefaction promises greater yields of liquid products at higher thermal efficiencies and lower cost than indirect processes. Direct liquefaction technology has not yet been demonstrated commercially; but, as a result of the Department of Energy program accomplishments to date, the commercial viability of this technology is ready to be demonstrated by industry with the support of the Synthetic Fuels Corporation.

Program Objectives

To achieve a supply capability for coal liquids that could fill any substantial portion of the gap between our total liquid fuel needs and the domestic liquids production from other sources, an extensive program of research, development, and demonstration is a prerequisite. The Department of Energy coal liquefaction effort has included extensive research and development in both direct and indirect liquefaction. Processes were supported from laboratory scale through continuous process development units; and the most promising processes were selected for advancement to the pilot plant stage, with those identified as meeting commercial market needs considered for technical demonstration. Department support activities provided back-up for advanced liquefaction processes and improvements in liquefaction technology in general. The result has been to facilitate the establishment of a synthetic liquid fuels industry.

Tracing the evolution of the Federal effort historically, section 6(b)(3) of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) required the Administrator of the Energy Research and Development Administration (ERDA) to assign program elements and activities to research, development, and demonstrations designed "to accelerate the commercial demonstration of technologies for producing syncrude and liquid petroleum products from coal" and "to determine the economics and commercial viability of the production of synthetic fuels such as hydrogen and methanol." Additionally, section 8(a) mandated research, development, and demonstration to "identify opportunities to accelerate the commercial applications of new energy technology and provide Federal assistance for, or participation in, demonstration projects (including pilot plants demonstrating technological advances and field demonstration of new methods and procedures, and demonstrations of prototype applications for the exploration, development, production, transportation, conversion and utilization of energy resources)." Subsequently, section 301(a) of the Department of Energy Organization Act of 1977 (P.L. 95-91) transferred all of these ERDA functions to the Department of Energy.

Through fiscal year 1981, the Government supported major activities in all of the legislatively mandated areas, with emphasis on the near-term objective of bringing the emerging liquefaction technology into the marketplace. Demonstration and large pilot plant activities are necessary to define the technical and economic risks associated with construction and operation of pioneer commercial plants. In the absence of normal profit potential for the private sector, a Government role in these projects was required to move liquefaction technology to prompt commercialization. In coal liquefaction, the demonstration and large pilot plant program sought to develop direct liquefaction processes to the point of commercial readiness. The research and development program always has been directed toward significantly improved process technology for both direct liquefaction of coal and the conversion of coal-derived synthesis gas to liquid fuels. Program activities focused on facilitating the establishment of a synthetic liquid fuels industry by developing and demonstrating (in cooperation with industry) advanced, environmentally acceptable processes of coal liquefaction that may eventually utilize a wide range of U.S. coals as feedstocks.

Starting in fiscal year 1981, the Government role in precommercial demonstration was shifted to the private sector when the Synthetic Fuels Corporation was created as a risk-sharing entity to provide the necessary incentives to industry. The Federal role switched to primary emphasis on supporting long-term, high-risk but potentially high-payoff research and development. Accordingly, the specific objectives of the current Department of Energy Coal Liquefaction Program responsive to this mandate are the following:

- To phase out primary involvement in pilot plant and demonstration projects, consistent with congressional action and Administration guidance

- To develop and evaluate long-range, high-risk liquefaction concepts that show promise of greater yields and high-quality liquid fuels, based on the types of coal that make up major U.S. resources

- To develop a data base concerning the environmental and health impacts of coal liquefaction processes, including strategies for mitigating adverse effects

- To transfer technical information developed by the program to industry

Specific historical and current program objectives are listed in Tables 2-1 and 2-2. No other U.S. programs duplicate these objectives. Present programs to develop coal liquefaction technology overseas, primarily in Germany, Japan, and Great Britain, are oriented towards the energy needs of those countries and the types of coal resources available to them.

The U.S. technology research and development program will continue to concentrate on studies that should improve the economic and environmental status of liquefaction technology in the future (addressing such issues as feedstock and product flexibility, along with key factors in process economics, including increased liquid yield, improved liquid quality, and better hydrogen management). These activities appear to be too long range for industry to undertake before a viable production industry is well established, yet it is desirable that this work be done now so that it can be available in time to support the rapid expansion of that industry on a self-supporting, nonsubsidized basis. Leaving the entire research and development program to private funding would delay the availability of coal liquids as a large-scale, competitive substitute for imported oil.

Program Results

Considerable progress has been made toward achieving the original objectives of the liquefaction program. By fiscal year 1981, the precommercial activity in coal liquefaction led to the construction and initial operation of two large (200 to 250 tons per day) direct liquefaction pilot plants based on the H-Coal catalytic liquefaction process and the Exxon Donor Solvent (EDS) liquefaction process. Two demonstration plants based on different versions of the Solvent Refined Coal (SRC) process were funded for the design, site selection, and environmental impact work. Government funding for one of these projects (SRC-II) was terminated in fiscal year 1981. In the case of the other (SRC-I), termination is being proposed during fiscal year 1982.

Because the national synthetic fuels program has been restructured to rely more heavily on private investment initiatives and less on the general taxpayer, responsibility for commercializing the technologies of alternative fuels is shifting to the private sector, with potential support from the Synthetic Fuels Corporation. Department of Energy funding is being ended for demonstration projects. Even at this stage, these four major project activities have contributed significantly to the objectives of the Department's coal liquefaction program by reducing the technical and financial uncertainties associated with commercialization of direct coal liquefaction technology by the private sector. Operation of the large pilot plants (H-Coal, EDS) verified the scalability of critical unit processes and components, demonstrating that each process can be operated at this scale. Design activities for the SRC demonstration plant indicate that those processes also can be scaled up to commercial size, using hardware and fabrication techniques available in the marketplace today. The studies associated with environmental impact statements for the various projects contributed substantially toward showing that these processes can be operated in an environmentally acceptable manner at commercial scale. In short, as a result of these program activities, direct liquefaction technology can be considered technically ready for commercial demonstration.

Continued Government support is anticipated for long-term, high-risk research and development projects that industry would not be in a position to finance. Improved technology for both direct and indirect liquefaction processes is being targeted, along with appropriate support studies to enhance both the environmental and economic outlook for a viable nonsubsidized synthetic liquids from coal industry. Although the broad payoff to the Nation from research and development efforts on coal liquefaction remains in the future, it is clear that this program has already laid a firm foundation for utilizing our vast coal resource base in an environmentally acceptable manner and thus decreasing U.S. dependence on foreign oil. The favorable impacts are likely to be widespread, for instance, in the area of economic security and national security, by reducing our vulnerability to import cutoffs; in the area of employment and investment opportunity, by virtue of the number of corporations involved; and in the area of price stability, by helping to limit the escalation of liquid fuel costs.

In addition to the four direct liquefaction processes th[illegible] were developed to the point where commercial-scale demonstration is technically feasible, programmatic efforts have succeeded in identifying and pursuing two promising new approaches to indirect liquefaction (synthesis gas conversion to liquid fuels). One involves the use of a liquid-phase reactor with a slurry catalyst; the other uses shape-selective catalysts and a fluidized-bed reactor. Each system promises significant improvements, a[illegible] both are being funded for further development. In the area of direct lique-faction, advanced concepts also are being studied, on the basis of rapidly growing understanding of key chemical steps in the efficient hydrogenation of coal. The most promising concept now being developed involves a two-stage configuration, in which the less selective noncatalytical dissolution step is integrated with a separate, highly selective catalytic hydrogenation step. The combination provides excellent hydrogen management, increased yield, and high-quality liquid fuel products. Substantial progress also has been made in using either natural or synthetic catalysts on a "once-through" basis; and there has been a notable improvement in synthetic shape[illegible] catalysts for direct catalytic liquefaction.

Pyrolysis processes also have been investigated because they [illegible] the potentially simple expedient of capturing natural hydrocarbon [illegible] locked within the coal structure itself. However, although much o[illegible] k[illegible] chemistry of pyrolysis has become evident, the outlook for a practical process along these lines has not improved greatly.

Studies on the environmental and health effects of coal liquefaction have clarified the key issues in this area. Apparently, most of the potential pollutant emissions can be controlled by carefully tailoring the known technology of air, water, and solid waste management to each specific process. Toxicity problems have been found with some of the liquid products of coal, but characterization studies have helped to define sources of the toxicity and have led to the identification of promising mitigation techniques. Some of the process modifications proposed also would tend to upgrade the products.

Specific program accomplishments for fiscal years 1978 to 1981 are shown in Table 2-1.

Projected Program Requirements

The budget for this program in fiscal year 1982 is $228.4 million. This includes approximately $130 million in SRC-I Demonstration Plant project design funds carried over from fiscal year 1981. It is the Administration's intention to terminate the SRC-I project design on June 1, 1982. Beyond fiscal year 1982, it is expected that the program will provide support for longer range, high-risk research and development activities with the objective of developing more efficient liquefaction technology that can utilize the entire U.S. coal resource base at lower cost. The emphasis will be on process concepts that are inherently more selective and efficient and that can achieve higher thermal efficiencies by reducing the amount of steam, oxygen, and hydrogen required. Research and development on a range of technology improvement options for both direct and indirect liquefaction will be pursued, and efforts will continue in developing appropriate strategies to mitigate undesirable environmental and health effects.

Until the synthetic liquid fuels industry establishes itself and a clear profit potential appears, Federal Government support for generic research and development in coal liquefaction seems to be the best way of ensuring that the benefits of process improvements will become available to the Nation's economy and the U.S. energy consumer on a timely basis. The general approach will continue to be to examine a number of liquefaction concepts in parallel, with only the most promising processes being advanced. Just as today's liquid fuels industry uses a variety of processes to handle natural crude oil, the future synfuel liquid fuels market will require a large number of plants that can produce significant quantities of diverse fuels and by-products from a variety of coals. In addition, the concepts under study provide complementary support to each other in improving overall operability, efficiency, and economics. Finally, this strategy ensures market competition, because no individual firm's technology will receive preferential support.

It is anticipated that major improved technology concepts will have been developed by the end of fiscal year 1987. In addition, a substantial technology base will be in place by then for process operation and scaleup of critical units, component and instrument development, and health and environmental effects (including mitigation strategies). These accomplishments should make improved liquefaction technologies technically ready for commercial application by industry during the 1990's. Table 2-2 contains additional information on projected program requirements.

If the support for the Department's Coal Liquefaction Program were reduced by 10 percent, the impact would be to stretch out and narrow the technical options that can be achieved. The adverse effect on the program probably would be larger than the proportion of funding reduction, because the fixed institutional costs borne by the program could not be reduced by much and the synergism inherent in a technical program that is well balanced among multiple projects would be lost. In a similar way, modest increases (10 percent) in program funding would allow a broader attack on the technology opportunities, but probably would not speed up the accomplishment of program objectives significantly.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(3) <u>SURFACE COAL GASIFICATION</u> (FE)

Coal gasification, the most versatile coal conversion technique, is being developed to help realize the full potential of U.S. coal reserves by changing heterogeneous feedstock into widely useable energy products. In this process, coal (a solid substance containing large amounts of carbon, hydrogen, and oxygen, as well as such impurities as sulfur, nitrogen, and trace metals) is converted into a fuel and/or synthesis gas.*

This conversion is accomplished by introducing a gasification agent (air or oxygen and steam) into a reactor vessel containing a suitably prepared coal feedstock under controlled conditions of temperature, pressure, and flow. The proportion of the various gaseous components leaving the reactor (such as carbon monoxide, carbon dioxide, methane, hydrogen, water, nitrogen, and hydrogen sulfide) is influenced by the type of coal, the composition of the gasification agent, and the controlled thermodynamics and chemistry of the gasification reactions. Once generated, this crude gas goes through a sequence of processing steps; the number and type are determined by the end products desired and by environmental requirements.

Various coal gasification processes can convert different types of coal into clean gaseous fuels with low- to medium-range Btu content, suitable for direct burning to provide energy for industrial processes and power generation; into a high-Btu (pipeline quality) gas that can be used as a substitute for natural gas; or into a synthesis gas, suitable for subsequent conversion into liquids that range from chemical feedstocks to high-grade transportation fuels.

Coal gasification technology, in itself, is more than a century and a half old. "First-generation" modern gasifiers (such as Lurgi and Koppers-Totzek) are available commercially, but they and the "off-the-shelf" process subsystems associated with them (for coal preparation and handling, gas cleanup, and methanation) have clear drawbacks as they exist now. They require considerable capital investment, have limited capacity, and have low conversion efficiencies that yield high-cost, marginally competitive products. Further, the only available pressurized system (Lurgi) must use non-caking coals and sized feedstocks; thus, its application in the United States is limited.

The Department of Energy's predecessor agencies initiated an extensive program of research and development on advanced gasifiers and gasification processes that might overcome these limitations. In the current Department program, promising concepts are advanced from the bench scale through the process development unit and/or proof-of-concept stage of development. There

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*See PAU #2, "Coal Liquefaction," for information about how synthesis gas fits into the process of indirect coal liquefaction.

is also a strong supporting program in materials, instrumentation, and component development, as well as studies to characterize effluents and to analyze process streams in a way that could lead to advanced effluent control through process optimization and/or new control equipment. These high-risk, long-range experimental and development projects are being performed to develop a technical data base that is adequate for transfer to the industrial sector for continued development and commercialization.

This program is much older than the Department of Energy. It was mandated originally by Chapter 23 of Public Law 65-259, which authorized and directed the Secretary of the Interior to "make experiments and investigations, through the Bureau of Mines, of lignite coals and peat, to determine the commercial and economic practicality of their utilization in producing . . . gas for power and other purposes." Later, the Office of Coal Research Act of 1960 (P.L. 86-599) directed the new office it established within the Department of the Interior to "develop through research, new and more efficient methods of mining, preparing, and utilizing coal," and this mandate was interpreted to embrace the study of coal gasification. In 1974, the functions of the Office of Coal Research were transferred to the newly created Energy Research and Development Administration (ERDA) by section 104(e) of the Energy Reorganization Act of 1974 (P.L. 93-438). Later that year, these functions were expanded by the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577). Section 6(b)(3) required the Administrator of ERDA to assign program elements and activities to research, development, and demonstrations designed "to accelerate the commercial demonstration of technologies for producing substitutes for natural gas, including coal gasification" and "to determine the economics and commercial viability of the production of synthetic fuels such as hydrogen and methanol." Section 8(a) authorized the Administrator of ERDA to "identify opportunities to accelerate the commercial applications of new energy technology and to provide Federal assistance for, or participation in, demonstration projects (including pilot plants demonstrating technological advances and field demonstrations of prototype applications for the exploration, development, production, transportation, conversion, and utilization of energy resources)." Finally, section 301(a) of the Department of Energy Organization Act of 1977 (P.L. 95-91), transferred all ERDA functions to the Department of Energy.

Program Objectives

Within the Department of Energy, the Surface Coal Gasification Program started with the mission of developing and demonstrating (in cooperation with industry) advanced and environmentally acceptable coal gasifiers and gasification processes that could use a wide range of U.S. coals as feedstocks for economical conversion into any one of the three gaseous products mentioned above.

However, in response to a number of changes in the U.S. energy supply situation that have occurred over the past 2 to 3 years, the program has been modified. Its emphasis has shifted from construction and development of hardware systems to the collection of a comprehensive data base on existing processes that industry can use to improve commercial systems or to scale up advanced systems. In addition, all effluents from operating plants are being characterized to quantify the environmental, health, and safety issues that must be addressed to permit the development of an acceptable synthetic fuels industry in the United States.

In short, the program has been redirected to more long-term, high-risk technology with the potential of making significant improvements in process efficiency, product cost, and environmental performance. Its goal is to assist industry to advance the state of the art of surface coal gasification technology to the point where the private sector can conduct normal risk assessments on which to base commercialization decisions. No duplicative (or even similar) work in advanced coal conversion technology is being performed elsewhere in the United States, and the availability or suitability of any work under way in other countries is uncertain. The specific contrast between historical and current program objectives can be seen by comparing Tables 3-1 and 3-2.

Apart from the fundamental stimulus of oil and gas price decontrol, U.S. private industry now has various financial incentives to press toward commercialization of coal gasification. These include cooperative agreements and loan guarantees, and they are administered principally by the Synthetic Fuels Corporation. They do not, however, provide any inducement for industry to initiate new studies or to continue research and development that is long range or high risk. If Federal funds were withdrawn from the redirected Department program, it is believed that commercial coal gasification project sponsors would concentrate only on first-generation technologies and accordingly would be subject to their limitations.

Program Results

Considerable progress has been made toward achieving the original objectives of the gasification program. A number of advanced coal gasification processes have been developed to the point where private industry can either implement them commercially or evaluate the current economic feasibility of producing a variety of products from coal resources available throughout the country with existing technology.

Several second-generation processes for high-Btu coal gasification have been developed through the pilot plant stage. Similarly, two medium-Btu gasification processes that are particularly well suited for the production of synthesis gas have been proven at the process development unit level. Promising processes for advanced (that is, third-generation) gasification also have been identified and are under development. All in all, confidence has increased in coal gasification technology, especially as a viable source of industrial energy. Additionally, the key elements of the support program needed for the future development of a large-scale synthetic gas industry have been identified.

Because the national synthetic fuels program has been restructured to rely more heavily on private investment initiatives and less on the general taxpayer, responsibility for commercializing the technologies of alternative fuels is shifting to the private sector, with potential support from the Synthetic Fuels Corporation. Department of Energy funding for demonstration projects is being ended, but the Department will continue to support and fund long-term, high-risk, and fundamental research and development projects that industry would not be in a position to finance.

These projects have the potential to effect significant improvements in process efficiency, product cost, and environmental performance. Current activities also include the collection of a comprehensive data base on existing processes, as well as on new concepts and on effluents.

The most direct beneficiaries of the surface gasification program have been natural gas and electric utilities, as well as engineering firms that have gained substantial knowledge about gasification technologies and experience in project development. Industries that are in a position to consider developing their own small gasification projects to help satisfy energy needs also have benefited. The commercial implementation of advanced coal gasification technologies might be expected to produce the following results in the future:

Regional Distribution of Gasification Facilities. Large coal gasification facilities will tend to be sited at the mine mouth, because of high coal transport costs and the comparative ease of transporting product gases and liquids. Although projects using current technology are likely to be concentrated in the Western United States, the development and commercial availability of advanced gasification technologies also will allow projects to be sited in the eastern and midwestern coal fields--near major gas distribution pipelines, industrial centers, and large power generating facilities. This should expand the use of high-sulfur eastern coals that are not easily marketable at present, and also shift the burden of water supply from water-scarce areas to areas where water supplies are adequate. It could bring new industries into areas where skilled labor and support facilities are available, but where unemployment rates are now high.

Flexibility of Coal Gasification as a Conversion Technology. Gasification of coal offers a potentially wide spectrum of alternate energy products, suitable for replacing oil and natural gas in many end-use applications. The successful implementation of advanced technologies thus can permit the use of an extensive fossil fuel resource (coal) to provide energy alternatives for essentially all sectors of the consuming marketplace.

Minimization of Environmental Intrusions. The coal gasification technologies available now can meet environmental standards, but their environmental impacts can be reduced further. A comparatively few large facilities will be more amenable to such control efforts than would widely distributed sites with less efficient control processes. Additional environmental benefits include (but are not limited to) reducing airborne emissions of sulfur compounds or particulates, eliminating the release of fuel-bound nitrogen, and generating data that can be used to further understand the mechanisms associated with acid rain.

The economic and social benefits from a new coal gasification industry might be offset in part by some adverse impacts, principally in such areas as land use, competition for available water resources, local air quality, and additional regional requirements for labor and state and local services. The relative importance of these factors may vary, depending upon the process and facility location; most will be determined by site-specific considerations. In most cases, adequate management of the resource and proper implementation of the technology can reduce environmental impacts significantly. Nevertheless, considerably more study should be devoted to institutional barriers (particularly as they exist in some of the sparsely populated regions of the West) before the full impact of a newly installed large synthetic fuels facility on a particular region can be determined.

The phaseout of six existing pilot plants and demonstration plant projects is on schedule; the procedures for an effective data base management system have been defined; the correlation between theoretical models and operational data has been initiated; a development program has been started to define key instrumentation materials and component concepts; and the environmental characterization and management programs are under way.

Specific program accomplishments for fiscal years 1978-81 are shown in Table 3-1.

Projected Program Requirements

The fiscal year 1982 budget for this program is $53.1 million. These funds will support the orderly phaseout of the large pilot plant and demonstration plant projects, and continue work on projects with objectives that satisfy the requirements of the redirected program. Beyond fiscal year 1982, the program will provide continued support of the redirected program consisting of projects considered as high-risk with long-range application, producing data essential to creating suitable incentives for industry to initiate efforts to commercialize the technology.

Table 3-2 outlines projected program requirements for fiscal years 1982-87. The projected average annual level of effort will produce a technical data base adequate to eliminate essentially all the technical risk associated with the construction and reliable operation of first-generation gasification technologies. It also will generate and confirm the scaleup criteria needed to reduce the technical risks involved in implementing more advanced technologies to a level that should be acceptable for industrial participation. Key concepts will be identified so that the advanced instrumentation techniques required for process optimization and control can be developed. Construction materials suitable for the harsh operating environments of gasification processes also will be determined, and essential operating components that are not normally a part of the off-the-shelf inventory of equipment supply firms will be identified and developed to a point where equipment manufacturers will find further development logical and desirable. In generating the environmental data needed to optimize the conditions of facility operations, these efforts will identify the techniques and define the approaches that are most suitable for minimizing potential environmental disruption from the implementation of these conversion processes by a synthetic fuels industry.

These activities are all essential to the establishment of a viable synthetic fuels industry, but private enterprise will not supply them without Government involvement because of the high economic risks involved in the early stages of technology development.

A 10-percent increase in the level of funding for this program would ncrease the rate at which data could be collected, accelerate the establishment of a confirmed data base, and encourage earlier industrial participation.

A 10-percent decrease in the level of funding would limit the amount of essential data available for the preparation of scaleup criteria, require delaying the characterization of in-process streams of gasification facilities needed to optimize the performance of these systems, and generally require postponing the implementation of second-generation technologies. As a result of such a reduction, any coal gasification industry would be characterized by the less efficient, more costly first-generation processes for several years longer than is currently projected. Commercial introduction of the more efficient but higher risk second-generation facilities could be set back by as much as 2 to 5 years.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(4) IN SITU (UNDERGROUND) COAL GASIFICATION (FE)

The coal resources of the United States are estimated by some to exceed 6 trillion tons, but only about 475 billion tons are economically mineable using current technology. Underground coal gasification (UCG) technologies have the potential of recovering energy from much of the unmineable resource and could quadruple the "mineable" reserves of the Nation.

Underground coal gasification is a deceptively simple process in principle. Wells are drilled from the surface to penetrate coalbeds several hundred feet underground. A flow path is established between pairs of wells, one well in a pair is ignited, and the combustion/gasification process moves through the coal--sustained by the injection of air or oxygen. When oxygen is injected, the produced gases consist primarily of carbon dioxide, carbon monoxide, hydrogen, small amounts of methane, and smaller amounts of higher hydrocarbons. This gas is then cleaned and may be used directly for power generation or industrial heat, or as a chemical feedstock for products such as methanol.

The technical feasibility of UCG has been confirmed through more than a dozen field tests during the past decade. Data from the tests show UCG's potential environmental advantages, lower product costs, and versatile product slate (including liquid transportation fuels). Quite naturally, commercial interest has been aroused; but the technology is not yet at a commercial stage, and, in fact, still involves high risk from a private investment point of view. A number of technical and operational issues will have to be resolved before industry is ready to turn UCG technology into a genuine alternative domestic energy source. Other investment opportunities, the high cost of capital, and the attendant financial and technical risks all combine to make the commercialization decision a difficult one; and the available data are not yet sufficient for a traditional risk analysis of the type that normally precedes private demonstration projects leading to commercial operations. Industry groups are now beginning preliminary field work in UCG on their own, but they have stated publicly that they rely on the Department of Energy program for the resolution of some basic technological issues. There have been numerous cost projections by industry to show that UCG-derived products should cost significantly less than other synthetic fuel alternatives, but there is still not much confidence in current methods of characterizing resources and in the ability to adjust processes to geologic anomalies. The inability to quantify risks associated with this emerging technology has added to a reluctance by industry to invest major capital.

Program Objectives

Section 5 of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), states that "The Congress authorizes and directs that the comprehensive program in research, development and demonstration required by this act shall be designed and executed according to the following principles." The principles are then stated, and in section 6 certain programs are specifically called out, including one "to determine the economics and commercial viability of in situ coal gasification." The sections were transferred intact to the Department by section 301 of the Department of Energy Organization Act of 1977 (P.L. 95-91).

The historical goal of the program was to support development of a regionally dispersed and economically competitive source of fuel for electric power, a synthetic gas for direct use as a fuel, or a new feedstock for production of synthetic natural gas and liquid transportation fuels. In cooperation with industry, at least one in-situ gasification technology was envisioned as reaching the commercial stage by the late 1980's. Although it is still believed that the underground coal gasification technologies would have a positive impact on the Nation's energy supply, it is no longer possible to continue funding the broad range of coal conversion technologies previously supported, and the current goal of the UCG program is simply to transfer all Department-developed data to industry as it continues to work on process development, while completing the postburn environmental monitoring on earlier field tests required by law. The UCG program will terminate after fiscal year 1982, and the only funding requested for fiscal year 1983 is to provide for the legally mandated environmental monitoring.

Tables 4-1 and 4-2 contain specific program objectives. No programs currently exist with similar objectives, nor are there any credible alternatives to the Department of Energy program. Industry is following the progress of the DOE program in UCG with increasing interest, but in the absence of further Department-funded work, industry can be expected either to terminate its own embryonic research or to advance at a very slow pace over an extended period of time.

Program Results

Since 1978, the Department of Energy program has included completion of three field tests and postburn evaluation of six DOE and pre-DOE tests and has accomplished many firsts. The technical objectives set for the field tests were met and technology transfer efforts appear to have been extremely successful. Several hundred persons have attended each of the annual symposia; industry has adopted the software for data acquisition and process control developed by the program; there have been extensive requests for advice and training; and engineers from private industry have been given repeated long-term assignments to work with Department teams. During a Gulf steeply dipping bed field test at Rawlins, Wyoming, the gas produced actually was used to fire a boiler.

Apart from its projected economic advantages, UCG offers potential environmental, health, and safety assets. Mining hazards would be eliminated. Coal ash would remain underground, thus minimizing solid waste disposal. The primary pollutants remaining after the underground burn are organic compounds, which would be absorbed by the char and coal surrounding the reaction zone. Air pollution problems can be addressed in the same manner as surface processes, utilizing off-the-shelf technology. Among the questions not yet resolved: How should ground subsidence be controlled? and How can the contamination of potable water aquifers be avoided?

The specific congressional order "to determine the economics and commercial viability of in situ coal gasification" has been followed. About two dozen economic studies relating to UCG have been prepared in the past few years, all based on data derived from the USBM/ERDA/DOE field tests. All show major cost advantages potentially associated with the process. Nevertheless, the commercial viability of UCG cannot be determined without a larger scale field test demonstrating the controlled burning of a large area of coal using several holes; and the rapidly escalating cost of such field tests has precluded this within established funding levels.

Table 4-1 provides a detailed listing of progress toward accomplishment of program objectives. These include demonstrating the technical feasibility of burning coal in situ under differing geologic conditions.

Projected Program Requirements

The fiscal year 1982 budget for UCG is $8.3 million. This will allow completion of the assessment and in-situ field testing of steeply dipping subbituminous coalbeds near Rawlins, Wyoming, and completion of several technology-base activities to a point where the data can be transferred effectively to industry. The activities include conducting large block tests at Centralia, Washington; completing data tapes of all process and thermal data from past tests; updating and publishing process models; completing university projects addressing basic kinetic studies of UCG processes; and evaluating and tabulating all relevant data developed in the program. The fiscal year 1983 budget request is for termination of program activities, and it provides only for completion of legally required postburn environmental monitoring. All other activities would end. Site environmental monitoring will continue at the fiscal year 1983 level of funding through fiscal year 1987. Table 4-2 provides additional information on projected program requirements.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(5) FUEL CELLS (FE)

Fuel cells convert chemical potential energy directly into electric power and heat through electrochemical reactions within individual cells. Unlike chemical storage batteries, they derive this chemical energy from a suitable fuel material that is replenished constantly from an external source during operation, so the fuel cells themselves need not be bulky to deliver substantial power continuously for an extended period. Unlike combustion systems, however, fuel within the cells is not "burned" in the conventional sense. Fuel cell power systems bypass the complexities of combustion-based technologies and their associated thermal-mechanicalelectric conversion steps. Furthermore, fuel cell efficiencies are not limited inevitably by temperature levels (Carnot efficiency), and they do not require the large, complex pollution control systems necessitated by burning most fuels.

A fuel cell powerplant consists of three basic subsystems: the fuel cell stack (or power section), the fuel processor, and the power conditioning section. The power section reacts hydrogen and oxygen to produce water, generate direct-current electric power, and release some energy in the form of heat. Since pure hydrogen is not readily available as a fuel source, the fuel processor is required to reform the fuel feedstock (hydrocarbon liquids or gases from varied sources) into hydrogen and carbon dioxide. The power conditioning module changes DC electrical current into AC for distribution to a grid connection.

Once this technology is fully developed, it is envisioned that the high electrical efficiency of fuel cell powerplants (40 to 60 percent) and their clean, quiet operation will permit them to be located quite close to points of end-use for both electrical and thermal energy. This would eliminate almost all of the distribution and transmission losses associated with remote generation. With cogeneration (that is, using the heat produced by the plant as a by-product of the chemical reaction that generates electricity), more than 80 percent of the energy available in the fuel can be put to practical use in such dispersed locations--compared to the average of 30 to 40 percent electrical conversion efficiency for today's conventional power generating systems. Moreover, emissions of environmentally hazardous pollutants such as NO_x, SO_x, and particulates from fuel cell powerplants are lower than those of most conventional fuel-burning generators by several orders of magnitude. Because fuel cell powerplants are typically assembled in modules, power capacity can be adjusted rather easily by incremental additions. For all these reasons, fuel cells are of potential value to a broad sector of the economy--if a number of practical engineering and economic questions about them can be answered satisfactorily during the next decade or so.

Although fuel cell plants are unlikely to compete in this century with traditional forms of electrical generation as central-station sources of baseload power, their use as decentralized "peaking units" could be extremely cost effective by reducing the need for new construction of large plants and additional long-distance transmission capacity. This would also ease land-use problems. Development of fuel cell technology may be considered in three successive stages or generations. In first-generation technology, fuel cell powerplants use methane, liquid petroleum gases, or petroleum distillates as feedstocks and phosphoric acid as the cell electrolyte. Phosphoric acid fuel cells operate at approximately 375° F, and their conversion efficiencies are projected to range from 38 to 44 percent. The second-generation approach utilizes the molten carbonate fuel cell which operates at higher temperatures (1,200° F) with a fused (liquid) carbonate salt as its electrolyte. Molten carbonate systems, designed to operate on coal-derived fuels, promise further gains in efficiency (to levels of 45 to 60 percent). In addition, steam exits the molten carbonate fuel cell at temperatures above 1,000° F, thereby expanding the ways in which this rejected heat can be applied. For example, exhaust steam could be directed through turbines to generate additional electricity. Beyond the phosphoric acid and molten carbonate concepts, a third-generation solid oxide fuel cell is in the early development stages. Solid oxide fuel cells operate at cell temperatures around 1,800° F, and they will accept fuels of lower purity than either the phosphoric acid or molten carbonate systems. In this case, the exhaust temperature would even be high enough to provide a heat source for a secondary generating system using thermionic conversion; and this is why the Department of Energy's small program in direct thermionic conversion is joined to its fuel cell effort.

Program Objectives

The goal of the Department's Fuel Cells Program has remained unchanged since the Department was established. The goal is to develop in a cost-shared program with the private sector, the high-efficiency (greater than 40 percent) fuel cell technology that will allow cost-effective displacement of oil and natural gas in the electric utility, commercial, and industrial sectors, using fuel cells and coal (or coal-based) fuels in an environmentally acceptable manner.

To realize the marketplace potential of fuel cell technology, the Department of Energy, in cooperation with end-use organizations, other research funding organizations, and manufacturers, developed a national plan that envisioned first-generation systems entering commercial service by about 1986. The Department's role in the National Fuel Cell Program has supported development of phosphoric acid cell and stack technology, system application studies, and conceptual designs leading to a preprototype test of a 4.8-megawatt electric utility powerplant in New York City in 1982-83 and a series of field tests of 40-kilowatt preprototype Onsite/Integrated Energy System (cogeneration) powerplants scheduled to begin in 1982. As of 1981, Department of Energy funding has been refocused on technology-base research and the development of high-risk, longer term elements of the national program, including advanced component/subsystems development and testing.

The legislative history of federally supported research and development in fuel cell technology dates back to 1960, when the Office of Coal Research Act of 1960 (P.L. 86-599) established the Office of Coal Research (OCR) ". . . to develop, through research, new and more efficient methods of . . .

utilizing coal." Under OCR direction, "Project Fuel Cell" was initiated to develop a commercial fuel cell power generating system using coal (or coal-derived fuels). In 1974, the Energy Research and Development Administration was created under the Energy Reorganization Act (P.L. 93-438) to provide greater effectiveness in planning, coordinating, and managing research and development programs for all energy sources. The Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) authorized the Administrator of ERDA to assign program activities including research, development, and demonstration structured "to commercially demonstrate the use of fuel cells for central station power generation." In 1975, Congressional Conference Report No. 94-696 authorized funds to initiate a program for a fuel cell demonstration powerplant; and in 1976 the Senate Interior and Insular Affairs Committee (Report No. 94-879) recommended an authorization to contract with private industry for demonstration of a 4.8-megawatt fuel cell module. Also during this period, authorizations were made for evaluation and development of advanced fuel cell technologies and for development of second-generation fuel cells capable of operating with low-Btu fuel gas from coal. The Department of Energy Organization Act of 1977 (P.L. 95-91) created the Department of Energy, and all fuel cell programs were transferred to the Department.

Historical program emphasis was on the design, development, and construction of a fuel cell demonstration plant based on phosphoric acid technology. Previous program objectives included development of fuel cell stack technology through cost-shared efforts with the Electric Power Research Institute (EPRI), the Tennessee Valley Authority (TVA), the Gas Research Institute (GRI), and individual utilities and manufacturers; the design, construction, and operation of a 4.8-megawatt utility demonstration fuel cell powerplant; and a series of field tests of a 40-kilowatt Onsite Integrated Energy System module for industrial and other cogeneration applications. Although the overall program goal has not changed, the Department's role has been refocused toward increased reliance on private sector support for phosphoric acid fuel cell demonstration efforts, with departmental emphasis shifting toward technology-base research and development. Specific program objectives are contained in Tables 5-1 and 5-2.

No programs exist whose objectives duplicate the various elements of the national program currently in place and there does not appear to be any viable alternative to Federal funding of the high-risk, high-payoff research and development components of the National Fuel Cell Program, at least in the immediate future. Since there is not yet a commercial fuel cell industry, private sector support of research--although substantial--is deterred by the uncertainties involved. Thus, withdrawal of Federal funds could be expected to cause significant delays and disruptions in the national program. Extensive negotiations, over a period of a year and a half, with members of the National Fuel Cell Coordinating Group (DOE, EPRI, GRI, TVA, DOD, and NASA), the manufacturers, and the users have already reduced the Department of Energy share of the funding; and, as a matter of policy, the Department has restricted its funding to high-risk technology development components of the national program for all three systems (that is, phosphoric acid, molten carbonate, and solid oxide cell and stack technology development only). However, there are two particular areas--the 4.8-megawatt and the 40-kilowatt field-test activities--where the private sector (EPRI, GRI, the manufacturers, and the users) would be likely to take over funding responsibility from the Department of Energy. With generation technology of the phosphoric acid fuel cell now entering the more costly verification and demonstration phases, private sector research and development investments are concentrating on ways to improve the performance of these early generation systems.

Program Results

Congressionally mandated milestones for fuel cell development relate to design, construction, and operation of fuel cell powerplants for utility application. The 4.8-megawatt phosphoric acid fuel cell demonstrator plant is scheduled to begin operation in New York City in 1982. Although the plant's original starting date has been delayed because of difficulties in auxiliary components, the phosphoric acid fuel cell itself is considered to be on the threshold of commercialization. Significant progress has also been made on the development of molten carbonate and solid oxide technologies, which will open up new uses for coal-derived gaseous fuels.

The technology of phosphoric acid fuel cells has made notable progress toward meeting the objectives set for it in cell power density, temperature, and conversion efficiency--objectives which seem essential to ensure private support for the commercialization phases. A steadily increasing share of program costs is being borne now by the private sector. With continued developmental success, it should be possible to reduce Department support of phosphoric acid fuel cell technology development for multimegawatt systems beyond 1984.

Progress in molten carbonate and solid oxide technology development has been steady and on schedule. Both systems promise superior efficiency, lower generating cost, and increased compatibility with dirtier fuels than do first-generation fuel cells.

The ultimate beneficiaries of the national fuel cell effort are residential and industrial users of electricity who may benefit from lower-cost power and reduced environmental intrusions. Other beneficiaries of the Department program include potential fuel cell manufacturers and private sector developers of the technology. Since there is not yet a commercial fuel cell industry, the private sector has lacked adequate marketplace incentives to assume full funding responsibility for research, development, and demonstration. Thus, Federal funds have substantially underwritten the development of unique complementary or competitive capabilities at United Technologies Corporation, Westinghouse Electric Corporation, the Energy Research Corporation (Division of St. Joe Minerals), Engelhard Industries, and General Electric. Support has also been provided to research and development at Argonne National Laboratory, the Jet Propulsion Laboratory, NASA Lewis Research Center, and Lawrence Berkeley Laboratory, as well as a number of universities and small businesses.

The development of fuel cell power generation technology broadly supports the national goal of reducing dependence on petroleum imports by extending the usefulness of conventional, domestic petroleum reserves (liquids and natural gas) through high conversion efficiencies, and by encouraging additional utilization of alternative, abundant domestic fuel resources (coal, oil shale, biomass, and waste-derived fuel feedstocks).

Potentially, fuel cells provide utility, industrial, and institutional users with an efficient, flexible, environmentally compatible form of energy conversion that could meet a range of applications in which combustion-based technologies might be inadequate or impractical. As noted above, fuel cell powerplants could be placed at or near major load centers. Their inherently high conversion efficiency, even at partial load conditions, should allow fuel cell systems to be used in applications where power and heat loads vary widely, without adversely affecting normal costs and reliable operation.

This country's lead role in fuel cell technology suggests that the United States will be able to export fuel cell technology in the future to all sectors of the energy economy overseas. Overseas markets could expand domestic employment in fuel cell and related industries and contribute to the national trade balance-of-payments.

Considering environmental prospects, fuel cell powerplants do not produce the gaseous (SO_x, NO_x) and particulate emissions associated with combustion and heat engine systems. High conversion efficiency, coupled with waste heat recycling, reduces requirements for the cooling water used in the condenser systems of most generators. Having no moving parts, fuel cells are free from their attendant noise and potential safety problems.

Program accomplishments during fiscal years 1978 through 1981 have tracked closely with the plans and objectives directed at achieving commercial demonstration of phosphoric acid fuel cell technology. Components were developed at successively increasing scales, and commercial requirements were defined. The desired cell operating characteristics were achieved for both the Multimegawatt (utility) and the Multikilowatt/Multimegawatt Onsite/Integrated (cogeneration) powerplants. Major components for the utility-type plant have been built, and they are being integrated and given "shakedown" tests prior to full-fledged demonstration.

A contract to manufacture multikilowatt onsite units for field trials has been signed. Research and development on advanced concepts has proceeded from evaluation of basic concept feasibility to bench-scale testing of materials, fabricating techniques, and confirmation of fuel cell performance characteristics. Table 5-1 contains greater detail on program accomplishments for fiscal years 1978-81.

Projected Program Requirements

The fiscal year 1982 budget for the Fuel Cells Program is $34.5 million. At this funding level, work can continue on phosphoric acid component technology and integration for both the multimegawatt electric utility and Onsite/Integrated Energy System projects. However, one of the two competing electric utility projects will be delayed approximately 1 year. Also, the scope of work on the Onsite/Integrated Energy Systems projects will be reduced slightly. A substantial reduction in Federal funding for the phosphoric acid fuel cell program is planned for fiscal year 1983, because technology development is expected to have progressed by that time to the point where the subsequent phase can be funded by the private sector.

The second- and third-generation programs will continue technology developments for fuel cell and stack configuration, aiming at technology readiness by 1987 for molten carbonate and by 1990-92 for solid oxide. However, systems analysis and testing of design concepts will be deferred.

An increase of approximately 10 percent in the program budget would sustain the development pace for only one phosphoric acid utility project. Additionally, increased funding would be allocated to the molten carbonate and solid oxide concepts, so that the pace of the second- and third-generation programs could also be sustained.

If the budget were decreased by 10 percent, the pace for the phosphoric acid utility project would be reduced, as would the pace of the molten carbonate and solid oxide activities.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(6) MAGNETOHYDRODYNAMICS (FE)

Magnetohydrodynamics (MHD) is a technology for directly converting heat into electricity and is potentially ideal for coupling with other generating systems to yield very high overall efficiencies. When a high-temperature (4,600° to 4,800° F), high-velocity, electrically conducting "coal combustion gas" plasma is passed through a magnetic field, electricity is generated. Even after leaving such an MHD generator, the "cooled" combustion gases (3,500° to 3,800° F) could be directed into a suitably designed but otherwise conventional steam-generating electric powerplant. Using coal as its primary fuel, an MHD/steam powerplant has the potential of being 50 percent more efficient than a conventional coal-fired powerplant.

Most of the MHD Program has been carried out under Department of Energy contracts with the private sector. These include two major Department facilities (operated by private contractors), as well as an engineering development portion of the program that involves some major industrial corporations.

Program Objectives

A significant amount of MHD research was carried out during the 1960's and early 1970's by other Government agencies (in particular, the U.S. Air Force and the Office of Coal Research in the U.S. Department of the Interior). The earlier work was funded primarily by the Air Force and to some extent by the U.S. Navy, and it was intended to develop military applications for MHD. Also of particular importance was the 1974 Agreement of Cooperation between the United States and the Soviet Union. This cooperative effort focused on joint work dedicated to the development of MHD technology, which would lead ultimately to the construction and operation of a commercial-scale MHD/steam-generating electric powerplant.

Legislation introduced in 1975 (primarily section 107 of the Department of Interior and Related Agencies Appropriations Act of 1974 (P.L. 93-404)) established a national MHD program under the direction of the Office of Coal Research. In section 107, that office was directed to initiate the design of an MHD Engineering Test Facility (ETF) large enough to provide a legitimate engineering basis for a commercial-scale MHD plant (500 megawatts-electric or larger). The program was transferred to the Energy Research and Development Administration (ERDA) in January 1975, and in September of that year ERDA established an MHD division to manage the program. In 1977, it was transferred to the Department under the Department of Energy Organization Act (P.L. 95-91).

The original goal was to facilitate by the 1990's the commercialization of coal-fired MHD plants that could meet environmental standards and produce electricity at a lower cost than conventional coal plants. The initial objective was to do this through the design, construction, and operation of an MHD commercial demonstration plant (identified as ETF). A two-step approach was developed. Phase I was to develop the engineering groundwork for the design of ETF. Demonstration of commercial readiness by the construction and operation of ETF would constitute Phase II. Table 6-1 cites specific historical objectives.

MHD technology is one of several advanced concepts for electric power generation from coal, all of which have substantial potential for increasing efficiency, reducing cost, and improving environmental performance of coal-based generation. The major competing technologies include fuel cells and the combined-cycle systems that use integrated coal gasification or pressurized fluidized-bed combustion. Weighing the program costs to complete development of MHD against the relative likelihood and timing of its success, the Administration has proposed to phase out this program in fiscal year 1982.

No other U.S. programs in MHD duplicate the objectives of this program. Although the private sector has the capability of developing the MHD/steam powerplant technology and other advanced technologies on its own, it appears unlikely to do so because of large development costs and the remaining technology risks.

There are various foreign MHD programs--in the U.S.S.R., the Netherlands, Poland, Japan, China, and India, among others. The United States now has cooperative agreements with the U.S.S.R., the Netherlands, and Poland, and there has been an extensive interchange of technical information with these countries. U.S. components are installed in test facilities in both the U.S.S.R. and the Netherlands. The Soviet program is the most significant of the foreign activities. At least three experimental MHD facilities are known to be operating in the U.S.S.R.

The Soviet Union has operated a 250 megawatts-thermal "U-25" MHD/steam electric pilot powerplant since the early 1970's, and a 30 megawatts-thermal "U-25B" MHD "topping" cycle, using the U.S. 5 Tesla superconducting magnet, since 1979. These test facilities have used natural gas as a fuel rather than the direct coal-fired approach used in the United States. A third test facility has been converted recently to burning coal. The results from these test facilities, plus additional small bench-scale tests, have led the U.S.S.R. to initiate the construction of a 500 megawatts-electric MHD/steam demonstration-size powerplant (using natural gas as a fuel). After gaining experience with gas-fired MHD plants, the U.S.S.R. has announced plans to construct coal-fired systems.

Soviet coal-fired MHD technology is not as far advanced as that in the United States, primarily because the U.S.S.R. does not have the superconducting magnet technology MHD needs. Nor does the U.S.S.R. have the experience in direct coal-fired powerplant systems that would be a requirement for U.S. MHD/steam powerplants because of fuel objectives in this country. In sum, the U.S.S.R. is believed to be behind the United States in coal-fired MHD channel/combustor development and in superconducting magnet development.

<u>Program Results</u>

To date, the MHD Program has been implemented in accordance with the legislative directive. The MHD activities have produced two test facilities and a significant technology base, thereby contributing greatly to the achievement of the original Phase 1 objectives.

Included in Phase 1 were the design, construction, and operation of two major facilities: the Component Development and Integration Facility (CDIF) of 50 megawatts-thermal input in Butte, Montana, and the Coal-Fired Flow Facility (CFFF) of a nominal 28 megawatts-thermal input in Tullahoma, Tennessee. Both facilities were activated in fiscal year 1981, and testing is now taking place.

The program with respect to magnet technology has involved three electrical equipment manufacturers and 20 subcontractors. Work on combustion technology has included several major equipment manufacturers in the "high technology" industry, architectural engineering firms, and electric utilities.

Results of engineering development tests indicate the preliminary technical feasibility of large-scale MHD/steam powerplants, both in high efficiency (50 percent or higher from coal pile to busbar) and in the durability and reliability of MHD electric power generator components. They also indicate that the MHD/steam powerplants should be capable of meeting or exceeding environmental requirements established by laws and regulations. Furthermore, using today's coal prices, the cost of electricity from early commercial versions of MHD plants has been projected to be 10 percent to 15 percent less than conventional coal-fired plants with flue-gas desulfurization (more than 30 percent less in mature plants). However, there is always some uncertainty as to whether technical goals and required economic performance can be achieved simultaneously.

MHD, if commercialized, would benefit the Nation's health, safety, and environment. The MHD/steam powerplants have the potential to more than meet all environmental standards; and, if they achieve the projected high operating efficiency, there would be a reduction in atmospheric emissions, coal mining, and water usage per unit of electricity produced. Again, as with all advanced technologies, large-scale testing would be required to confirm these projected benefits.

The MHD Program has had several significant accomplishments: MHD generator life has been extended from tens of seconds in the early 1970's to thousands of hours. Service life has been extrapolated to more than 8,000 hours in a 20 megawatts-thermal scale engineering test at the AVCO Mark VI site, under operating conditions closely simulating those anticipated in large, high-efficiency baseload systems. Studies conducted for the MHD division indicate that 2,000-hour channel durability is sufficient for early commercial applications.

Fifteen-percent energy extraction has been attained in 75 megawatts-thermal scale MHD shock-tube tests. Initial scaling tests have been conducted at 300 megawatts-thermal scale (at Arnold Engineering Development Center) to further verify projections of performance levels. The full projected 10.5-percent enthalpy extraction (at a magnetic field of .2 Tesla) has been attained to date, compared with the goal of 12 percent (at a magnetic field of 4.5 Tesla to 6.0 Tesla) by 1984. Once again, as with all advanced technologies, confirming the ability of an MHD plant to meet commercial economic criteria would require large-scale testing.

A 40-ton superconducting high-field magnet (5 Tesla) has been built in the United States and operated successfully in integrated MHD topping-cycle tests in the U.S.S.R. at 30 megawatts-thermal scale. A 200-ton superconducting magnet--intended for use in a 50 megawatts-thermal to 100 megawatts-thermal MHD test facility (CDIF or CFFF)--has also been constructed and was tested in August 1981 exceeding the design magnet field of 6 Tesla. Coal-fired MHD combustors of varied designs have operated successfully at scales of 5 megawatts-thermal, 10 megawatts-thermal, and 20 megawatts-thermal, and they have achieved the required temperatures (maximum combustion temperature of 5,000° F) with very low heat losses, high carbon conversion, relatively high electric conductivity for the plasma, and a high slag rejection. Presently, the most promising design is being scaled up to 50 megawatts-thermal.

State-of-the-art, energy-efficient processes have been identified for the reprocessing of seeding material (potassium sulfate to potassium carbonate), including at least one industrially available process (Engle-Precht). Seed recovery capabilities of 90 percent in 10 megawatts-thermal coal-fired integrated system tests and 99-percent recovery in 250 megawatts-thermal gas-fired integrated plant tests have been demonstrated. It is projected that 90 percent to 95 percent seed recovery will be required for coal-fired commercial MHD systems.

Substantial experience with integrated systems has been compiled. A coal-fired, combined-cycle, integrated MHD/steam system has operated in this country at a 10 megawatts-thermal scale since the mid-1970's; and the 28 megawatts-thermal scale facility at CFFF will also be able to test integrated systems in the near future. At the AVCO Mark VI facility, MHD topping-cycle tests with simulated coal-firing at the 20 megawatts-thermal scale have been coupled to the Massachusetts power grid. In the U.S.S.R., the U-02 10 megawatts-thermal scale integrated system has been operating since the early 1960's (first with gas-firing, but now as a coal-fired unit). The Soviet Union's 250 megawatts-thermal scale U-25 combined-cycle plant has achieved its design objectives while operating since 1972 on gas; and that country plans to have a gas-fired 1,200 megawatts-thermal MHD plant on line by the middle to late 1980's.

A vertical slice of a prototypical regenerative air heater (under development for use in second-generation MHD plants) has been operated at about 2,700° F with simulated coal-firing, accumulating more than 2,000 hours of test experience to date; and Fluidyne projects a service life for the materials of more than 10,000 hours. (On the commercialization schedule drawn up by the MHD division, first-generation MHD plants were projected to use oxygen enrichment to obtain up to 5,000° F combustor flame temperatures.)

A major effort has been made to foster industrial participation in the MHD Program. The Advanced Power Train Program initiated in fiscal year 1981 brings together in a combined fashion the major equipment manufacturers with the "high-technology" industry, with the architectural engineering firms, with electric utilities, and with others to pursue development of MHD systems. In addition, independent U.S. utilities and industrial groups have been formed to review, guide, and support MHD systems development. Along with a substantial MHD technical base, there is an extensive base of industrial and commercial practice that has been called on to support all of the major elements of the coal-fired MHD power generating system test facilities operated to date; it would be directly supportive of scaleup to a fully integrated plant. For example, information, data, and practice can be drawn from the utility industry in the areas of cyclone and pulverized-coal combustors and in steam-generating equipment, from the high technology industries in superconducting magnets and advanced diagnostics, from the air pollution control industries, and from the chemical and paper process industries in process steam boiler design and in seed regeneration.

Milestones of specific accomplishments are outlined in Table 6-1.

Projected Program Requirements

Although MHD is one of four advanced fossil energy technologies that offer significant potential for reducing the cost of electricity and improving the environmental performance of coal-fired powerplants, budget reductions make it necessary to end Federal support during a period of fiscal restraint because of the high potential program costs. No funds have been requested in fiscal year 1983 for continuing the development and demonstration of MHD. In order to facilitate the phaseout of Departmental efforts, the MHD program will be redirected in fiscal year 1982 to close out facilities and bring other ongoing efforts to an orderly conclusion.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(7) HEAT ENGINES (FE)

Program Objectives

The Heat Engines Program at the Department of Energy is designed to develop the technology base needed to make stationary turbines and diesel engines capable of operating on coal-based and other synthetic fuels. While separate and distinct from the programs for Combustion Systems and Advanced Environmental Control Technology (PAU's #8 and #10), the Heat Engines Program shares with them the goal of developing more efficient systems for generating electricity with better environmental performance. The Department's role involves applied material and fabrication developments, burner rig and engine tests, development of new combustor engineering concepts, and engineering performance evaluations.

One primary purpose of the turbine technology being developed is its use in combined-cycle plants that produce electricity (that is, those in which the exhaust heat from one generating process--the topping cycle--is utilized by another generating system that can operate efficiently at lower temperatures--the bottoming cycle). One concept employs a coal gasifier to generate coal-derived fuel gas, which is used in a combustion turbine as the topping cycle. In this case, the gasifier development is contained in other Department programs (see PAU #3, "Surface Coal Gasification"), and the turbine development is contained within the Heat Engines Program. Another concept involves heating a turbine's working fluid outside the turbine itself. The Heat Engines Program embraces the development of the primary heater as well as the gas turbine used in the latter system--again a topping cycle. Hot exhaust from either gas turbine would be routed to a steam generator, from which steam can be directed through a steam turbine to drive an electric power generator, thus producing more electricity. The higher the temperature at which the gas turbine operates, the higher its efficiency. Present turbines in combined-cycle systems can operate at temperatures up to 2,000° F, and this program is trying to extend the operating range to 2,600° F to 3,000° F.

Another major purpose is the development of smaller turbines and diesel engines that can operate on coal-derived fuels (liquids, gases, coal-liquid mixtures, and beneficiated coal) for use in small electric utility and many industrial applications, including cogeneration. This program entails basic development of combustion mechanisms for the engines, materials and component development and testing, and engineering performance evaluations. This program is attempting to extend the application of such small turbines and diesel engines to include the use of fuels heretofore not in their repertoire, with emissions that are environmentally acceptable.

Section 103 of the Energy Reorganization Act of 1974 (P.L. 93-438) mandates ". . . conducting research and development, including demonstration of commercial feasibility and practical application of . . . utilization phases related to the development and use of energy from fossil . . . and other energy sources." Further, section 6(b)(3)(C) of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) directs research, development, and demonstration designed "to demonstrate improved methods for the generation, storage, and transmission of electrical energy through advances in gas turbine technologies, combined power cycles, and the use of low-Btu gas." These responsibilities were transferred to the Department of Energy under the Department of Energy Organization Act of 1977 (P.L. 95-91).

Prior to fiscal year 1982, the goal of the Department's program was full development of improved stationary gas turbines and engines that could be fired with minimally upgraded coal- and shale-derived fuels, thereby displacing premium oil and gas fuels for higher priority applications. Activities were oriented towards developing technology for critical engine components, and Table 7-1 outlines the degree to which more specific objectives have been attained.

The refocusing of coal research and development within DOE's fossil energy program has resulted in a recommendation by the Administration to phase out the Heat Engines Program at the end of fiscal year 1982. The technology verification tests for high-temperature turbines (Phase III) will not be initiated in fiscal year 1982 as originally planned. An orderly phaseout of all other efforts will be conducted. Objectives that will be reached in fiscal year 1982 are summarized in Table 7-2.

There are no other Governmental or private projects with duplicative objectives; however, some having similar or complementary objectives should be noted, so that their relationship to the Department of Energy's efforts will be clear:

- The Southern Cal Edison/EPRI Cool Water Project is directed toward a gasifier combined-cycle system using the 2,000° F turbine-inlet temperature permitted by current gas turbine technology. Because of the excellent environmental performance projected for such systems, this one is targeted for a site with severe environmental constraints. However, turbine-inlet temperatures in the 2,600° F to 3,000° F range will be required for the economic performance needed if this environmentally superior technology is to be adopted widely.

- Several other federally funded programs are investigating the use of synfuels in diesel engines for highway vehicles and in aircraft turbines; but those represent different types and size ranges from the technically distinct utility equipment that is the object of the Department's Heat Engines Program.

- The gasifier/molten carbonate fuel cell system under the Fuel Cells Program (PAU #5), the advanced emission control system under the Advanced Environmental Control Technology Program (PAU #10), and the Pressurized Fluid-Bed Program under the Combustion Systems Program (PAU #8), all share a common general goal with the High-Temperature Turbine Technology (HTTT) program of supporting the development of advanced coal-fired electricity generating systems that will have improved environmental and economic performance. While none of these technologies is sufficiently mature to allow a definitive comparison, performance estimates based on current data indicate that each may capture a significant market share. Individual differences among them in capital cost, emission performance, and efficiency are likely to be matched against site-specific requirements.

Program Results

The original objectives of the Heat Engines Program included full development of turbine combustors that could operate on liquid synfuels, determination of the operational performance of stationary diesel engines using liquid synfuels, and technology-readiness demonstrations of HTTT cooling technology and the atmospheric fluidized-bed primary air heater technology. The main objectives of the liquid synfuel portions of the diesel and turbine combustor programs have been achieved. As a result of refocusing on technology-base activities, however, the technology-readiness demonstrations on the HTTT and air heater projects are being terminated at approximately 40 percent and 30 percent completion, respectively.

To the degree that this program's goals, in conjunction with those of the Combustion Systems and Advanced Environmental Control Technology Programs, are achieved, there should be a beneficial impact on the Nation's security and economy as a result of increased use of coal in place of oil and gas within the utility and industrial sectors. Equally important, national benefits are likely to result from the improved environmental performance of the new technologies as the direct use of coal increases greatly in the longer term. All programs conform fully to relevant health and safety practices and standards; and higher generating efficiencies mean that less coal per kilowatt-hour needs to be burned, thereby reducing environmental problems from mining through stack emissions.

The content of the program is within the specifications and spirit of the authorizing legislation. Program accomplishments during the fiscal years 1978 to 1981 period have been consistent with achieving DOE's stated objectives. Accomplishments include successful bench-scale demonstration of HTTT blade cooling components, initial data about diesel engine operability on liquid synfuels, and successful operation of turbine combustors operating on liquid synfuels in terms of NO_x emissions. Table 7-1 provides a more detailed description of program accomplishments.

Projected Program Requirements

The fiscal year 1982 budget is $15.4 million. It provides for technology base efforts in low-NO_x combustors, the completion of Phase II of the primary heater development, a preliminary evaluation of the potential of coal-water slurries as a diesel fuel, and the continuation of applied research on the engineering of alloys and coatings to enable acceptable combustion zone durability for both gas turbines and diesel engines. These activities, except for the coal-water slurry evaluation (which is to be completed), will be phased out in fiscal year 1982.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(8) COMBUSTION SYSTEMS (FE)

Program Objectives

The Department of Energy's Combustion Systems Program is a companion to the Department's heat engines and control technology systems programs (see PAU #7, "Heat Engines," and PAU #10, "Advanced Environmental Control Technology"). The joint goal of these programs is to establish the technology base for combustion equipment that can substitute coal and coal-derived fuels in existing oil- and gas-burning systems (thus reducing the consumption of these premium fuels) while also minimizing environmental effects and producing electricity and thermal energy at competitive costs or even more economically than is now possible. DOE carries on component and subsystems testing at laboratory scale and makes engineering performance evaluations and systems tests at the level of process development units. The Department does this specifically for atmospheric and pressurized fluidized combustors to burn coals of all ranks and grades, for coal-water slurries, and for advanced coal combustors. The last two systems are intended either for use in new installations or for retrofit on existing oil- or gas-designed equipment.

In fluidized-bed combustion, crushed coal is mixed into a bed of inert ash and limestone or dolomite, and the individual particles are suspended by an upward flow of gas, so that the entire mass assumes the characteristics of a fluid while burning takes place. Depending on the pressure regime selected, a system may be atmospheric fluidized-bed (AFB) or pressurized fluidized-bed (PFB). In either case, the very large surface area and the constant movement of the coal particles ensure rapid and complete combustion. The limestone or dolomite reacts with sulfur in the presence of oxygen to form a solid sulfate material that tends to sink to the bottom so that it can be disposed of easily. Fluidized-bed boilers are compact and operate at overall temperatures appreciably lower than those in conventional boilers, thus inhibiting formation of nitrogen oxides. Both AFB and PFB can operate on a wide range of coals and other fuels. Because PFB operates under pressure, it can be used in a combined-cycle system to improve overall plant efficiency.

Coal-water mixtures are mixtures of approximately 70-percent pulverized coal and 30-percent water. Limited, small-scale tests have shown that such mixtures can be pumped and burned in a manner similar to oil. The primary technical issues that remain unresolved in relation to them include the degree to which flame characteristics can be made to match those required by oil-designed equipment; the downstream effects of coal ash on heat-transfer equipment; the acceptability of whatever modification and derating of burners and systems would be required to accommodate these off-design effects; and the cost/performance trade-offs dictated by the degree of coal cleaning that might be required.

Advanced coal combustors are physically small devices capable of being retrofitted to oil-designed equipment. By providing high combustion intensity and a means of trapping the ash or slag, such modules minimize the adverse downstream ash effects that would normally preclude such fuel switching.

The authorizing legislation for this program is the Energy Reorganization Act of 1974 (P.L. 93-438). In section 103, it mandates ". . . conducting research and development, including demonstration of commercial feasibility and practical application of . . . utilization phases related to the development and use of energy from fossil . . . and other energy sources." This responsibility was transferred from the Energy Research and Development Administration to the Department of Energy under the Department of Energy Organization Act of 1977 (P.L. 95-91).

Prior to fiscal year 1982, this program sought to develop and demonstrate a reliable AFB or PFB combustion system (or coal-oil mixture), so that "first-generation" systems or concepts were emphasized and the Department became involved directly in pilot and demonstration activities designed to accelerate commercialization by providing operational data and experience at full scale. Specific historical program objectives are summarized in Table 8-1.

Although the program had always included extensive technology-base development, its goal has now been refocused to concentrate on the earlier research and development phases. The Department of Energy's current role is limited to accelerating the development of the most advanced technology, leaving decisions regarding commercializing such technology to the private sector. The current goal is to develop the technology base for reliable PFB systems and coal-water mixtures that will allow for the cost-effective displacement of oil and natural gas in the industrial and utility sectors by coal or coal-based fuels in an environmentally acceptable manner, while phasing out the development and assessment of the AFB technology base in fiscal year 1982. A summary of current program objectives is shown in Table 8-2.

There are no programs in the United States with duplicative objectives, but there are some whose objectives are similar or complementary:

- The Electric Power Research Institute (EPRI) has initiated a project to demonstrate coal-water mixtures in a utility boiler designed originally to burn oil. Although this project is expected to furnish useful data for the Department effort, it will not by itself provide a basis for extrapolation over the full range of boiler sizes and designs characteristic of the industrial sector (which represent the broader object of the Department of Energy program). This applies also to the increasing private-sector activity among potential coal-water mixtures suppliers, whose primary interest is to establish the economics of the production of coal-water mixtures with low-risk coal-designed-but-oil-fired utility units. In each case, the private-sector activities are depending on the Department's program to provide the utilization data base that will be required to accomodate most of the industrial sector.

- The Tennessee Valley Authority and EPRI have a 20-megawatt AFB pilot plant under construction and have proposed a 200-megawatt AFB utility demonstration plant. In contrast to the industrial focus of the Department of Energy program, this effort is directed exclusively toward utility technology.

- Twelve boiler manufacturers are involved currently in design or construction of about 40 first-generation AFB industrial boiler units. These activities, which will expand the data base on economic and environmental performance, will not touch the advanced concepts or the fuel-flexibility issues addressed under the Department's program.

- American Electric Power/Stal-Laval have proposed a PFB pilot plant, to be followed by a 170-megawatt demonstration plant. However, plans for this private-sector effort assume that design data will be available from an ongoing Department of Energy program.

- Other Department programs share with the PFB effort the general goal of supporting the development of advanced coal-fired electricity generating systems with improved environmental and economic performance. These include activities relating to the development of gasifier combined-cycle systems, such as the High Temperature Turbine Technology Program discussed in PAU #7, "Heat Engines"; the development of advanced emissions control technologies for conventional coal-fired systems, such as those discussed in PAU #10, "Advanced Environmental Control Technology;" and the gasifier/molten carbonate fuel cells systems discussed in PAU #5, "Fuel Cells."

A comparison of the programs reveals that each is directed toward a different segment of the overall consumption sector, which is large and heterogeneous. Because of differences in capital cost, emission performance, and efficiency, there will probably be site-specific requirements for all.

Program Results

The original objectives of the Department's program included construction and operation of a 30-megawatt AFB utility demonstration plant, a number of industrial-sized AFB demonstration boilers, a PFB pilot plant, and demonstration of coal-oil-mixture (COM) technology. The COM project was completed, and that technology is considered commercial. The AFB demonstrations also were completed. As a result of the recent program decision to concentrate on technology-base activities, negotiations are being conducted to cap the DOE cost for the PFB pilot plant project with fiscal year 1982 funds and to provide no funds in fiscal year 1983. Continued participation in the International Energy Agency's PFB research facility project at Grimethorpe in the United Kingdom will also provide data for the technology base in this field. Furthermore, as noted above, a PFB demonstration plant of 170-megawatt capacity is now contemplated by private industry.

Before and after the policy reorientation, the Department of Energy's Combustion Systems Program has performed its functions within the spirit and intent of the authorizing legislation referenced above, and it has met or is meeting planned objectives on schedule. Although the authorizing legislation did not provide quantitative guidance in terms of either scope or schedule, it is believed that congressional objectives are being met on a schedule that reasonably parallels annual congressional budget actions.

Accomplishments during fiscal years 1978 through 1981 include construction of a 30-megawatt AFB utility demonstration plant and operation at full power, construction and operation of three AFB industrial demonstration plants, commissioning of a PFB research facility, completion of the COM project, and initiation of the coal-water mixtures and advanced combustion programs. More detailed program accomplishments are shown in Table 8-2.

Especially to the degree that the longer term program goals are eventually achieved, the Department's program should benefit the Nation's security and economy through increased direct use of coal in place of oil and gas in the utility and industrial sectors. Improved environmental performance from the emergent technologies also promises nationwide benefits because of the greatly increased direct use of coal projected for the United States. If it does prove technologically and economically feasible to retrofit coal-water mixtures and advanced coal combustors, an especially significant result will be the capability to increase coal's share of domestic energy consumption with capital investments that are modest compared to other options. In light of coal's relative abundance, this is an important consideration in national efforts to decrease dependence on costly and uncertain oil imports.

Projected Program Requirements

Fiscal year 1982 budget authority for this program is $41.0 million. Activities involving AFB and coal-fired, ash-retaining combustors will be phased out this year. Beyond fiscal year 1982, PFB support activities will be continued for the purpose of developing a sound technology base for understanding environmental and operational performance. In addition, work will continue on the prototype investigation of coal-water mixtures. Some of this work is still only in its initial stages, but in the aggregate it should provide the basis for eventual development of coal systems that can directly replace oil in both new and existing installations.

The projected average annual funding level will provide for a continuation of fiscal year 1983 activities. It is anticipated that the PFB data base development will be completed in 1987, and that the coal-water mixtures data base development will be completed by 1986. Table 8-2 provides more detail on projected program requirements.

With an annual budget increase of 10 percent, the coal-water mixtures program could be completed in fiscal year 1985. If the annual budget were reduced by 10 percent, the scope of the PFB and coal-water mixture programs also would be reduced.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(9) ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT (FE)

Program Objectives

The Advanced Research and Technology Development Program (ARTD) plays an important role in the Department of Energy's fossil energy activities through the development of a comprehensive technology base in coal. Substantial advances in technology rest both on a firm understanding of the underlying sciences and on the novel application and development of scientific and engineering principles to advanced prototypes demonstrating scientific feasibility. The ARTD Program supports many relatively small projects that are selected to uncover basic knowledge essential to developing coal technologies. ARTD efforts consist of laboratory-scale basic and applied research and exploratory development, and they cover a wide range of scientific and engineering disciplines. Most of the work falls into three technology areas: direct utilization, processes, and materials and components. A fourth area in the ARTD Program, University Coal Research, supports university research in all coal technologies.

The original legislative mandate for the ARTD Program is contained in section 3(b)(1) of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577). Congress declared the purpose of the act to be "to establish and vigorously conduct a comprehensive, national program of basic and applied research and development, including . . . all potentially beneficial energy sources and utilization technologies within ERDA." This mandate was transferred to DOE by the Department of Energy Organization Act of 1977 (P.L. 95-91).

ARTD has addressed this mandate as the most forward-looking component of the Fossil Energy Program, supporting research to develop a base of coal technology knowledge and to discover advanced concepts for significant process improvement, ultimately accelerating the direct substitution of coal for oil and natural gas in the industrial and utility sectors.

General program objectives are summarized in Tables 9-1 and 9-2, but it should be pointed out that more than 400 projects in all are being conducted and that each has its own specific objective. These projects are carried out by industry, energy technology centers, national laboratories, and universities. The program as a whole is not duplicated anywhere else, either in other Government agencies or in the private sector. Some other segments of the fossil energy research and development group within the Department of Energy have redirected their programs to longer term, high-risk activities, but those "line" programs are primarily concerned with advanced exploratory engineering development, while ARTD is limited essentially to basic and applied research. Activities sponsored by the National Science Foundation and by the Department's Office of Energy Research are much broader in focus, instead of being oriented specifically to coal and the reactions it undergoes. The Electric Power Research Institute primarily supports projects dealing with engineering development rather than those projects dealing with fundamental or applied research. The Gas Research Institute has a high-quality research program, but funds are quite limited (less than $1 million in fiscal year 1981 for fundamental coal research), and the projects that the Institute supports in this area are related only to coal gasification.

Program Results

Because of the long-range nature of the ARTD Program, the degree to which its original objectives have been achieved can be estimated only approximately. The objectives for the first 4 years are judged to have been substantially achieved (better than 95 percent).

This program contributes to the advancement of all other Department of Energy coal programs. It has produced a continuous stream of data directly relevant to advanced coal conversion and utilization technologies, and virtually all of this new knowledge has been transferred to interested parts of the private sector. In addition, ARTD has succeeded in encouraging the U.S. academic community's involvement in coal research.

The principal beneficiaries of the program have been industrial organizations, since the research done in this program has a longer term focus than their development activities have--whether they be in improving the efficiency and/or environmental performance of coal and synthetic fuel combustion processes, converting coal to clean gas and liquid fuels, or getting better performance from materials and components in coal utilization systems. The recently initiated University Coal Research project has directly benefitted more than 300 faculty and students in universities by improving their background and knowledge in coal-related technologies. In the long run, if the private sector perceives that the economic incentives are sufficient to justify investments in large-scale development and commercialization of technology based on ARTD results, the national economy as a whole will benefit through increasing substitution of coal and coal-derived fuels for petroleum and natural gas. There may be environmental benefits, too, because the activity includes projects on advanced concepts for mitigating adverse environmental effects from coal conversion and utilization processes. For example, some projects are exploring new concepts in staged coal combustion to reduce nitrogen oxides (NO_x) emissions; others are investigating new approaches to treatment of wastewater from coal gasification and liquefaction systems. Projects of this type may be the first step in developing processes that will enable powerplants to operate more economically and efficiently while maintaining sulfur oxides (SO_x), NO_x, and particulate levels below Federal standards.

The ARTD Program is directly responsive to the criteria set by Congress for Federal funding of research and development in coal-related technologies. These are cases in which it is unlikely that national needs will be met in a timely manner without Federal assistance; or in which normal commercial utilization of proprietary knowledge appears inadequate to encourage timely results; or in which the magnitude of the required investment exceeds the financial capabilities of the potential non-Federal participants; or in which the opportunities to induce non-Federal support are limited by regulatory actions or other factors. Since all ARTD activities are described by at least one of these cases, the congressional objectives for this program are being met.

During fiscal years 1978 through 1981, the ARTD Program was particularly productive with respect to the number of activities started and their results. Almost 900 fundamental studies and experiments on coal utilization processes and coal-related process engineering science were sponsored, and almost 80 significant technology spinoffs and transfers to development programs resulted. Close to 200 significant scientific discoveries and process concepts were evaluated. All of the resultant new technical and scientific knowledge was transferred to interested private sector parties, via more than 4,000 publications and at least 1,000 presentations, with 26 workshops attended by more than 4,000 individuals. In addition, at least 28 patent applications have come out of the program. In the University Coal Research area alone, 73 grants over 2 years have supported the efforts of 300 faculty and students.

These numbers are only a quantitative reflection of accomplishment, however. The quality of research is the most important measure of success for this type of activity; and it has been high. The ARTD Program has developed computer models for coal gasification with proven industrial applications; it demonstrated that staged combustion of coal with preheated air can control NO_x emissions; it showed that coal-water mixtures would work as fuels; and it found a method of regenerating methanation catalysts in situ. These are only highlights; the full value of countless additions to the coal technology base from virtually all projects is difficult to estimate. A more detailed treatment of the performance and cost of this program can be found in Table 9-1.

Projected Program Requirements

The fiscal year 1982 budget for this program is $56.3 million. The ARTD Program is an integral and necessary part of any conceivable research and development program on fossil energy because it provides the general technical knowledge (and, occasionally, breakthrough ideas) that carry such a program to successful completion. The Federal Government's role in supporting ARTD is justified by the inherent high-risk and long-term nature of such activities. Such a role is supportable whether technology development activities are conducted by the Federal Government or by the private sector.

Table 9-2 provides details on projected program requirements and budget justification. The fiscal year 1983 level of funding, projected through fiscal year 1987, will continue to generate advances in coal-related sciences and exploratory engineering development that support Federal and private sector coal technology development. Program objectives will change somewhat, with the termination of University Coal Research activities, as well as activities in the areas of improved heat exchangers, instrumentation and control research, engineering analysis, and technology base synthesis, which will be phased out in fiscal year 1982. The rest of the activities will continue at reduced funding, although it will have increased importance to the rest of the fossil energy program. Since the objectives governing the remaining portion of the program are of a continuing nature, there is no estimated year of program completion.

With a 10-percent increase in the level of funding, basic and applied research in materials, direct utilization, and processes would be broadened. Materials research would be started in areas that traditionally have not been supported by this program in the past, such as fuel cells and pollution control. Utilization and process research would concentrate on the basic scientific areas and problems underlying these technologies.

With a 10-percent decrease in funding, research in areas perceived to be less important would be dropped, research in other areas would be slowed down and spread out, and fewer innovative ideas would be explored and evaluated. The specific effect of this decrease in research activity is difficult to predict, but the overall general effect would manifest itself over time as a decrease in the pace of coal technology development.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(10) ADVANCED ENVIRONMENTAL CONTROL TECHNOLOGY (FE)

Program Objectives

The principal purpose of this program is to establish basic technologies required to reduce costs and minimize environmental effects in the production of electrical or thermal energy from coal or coal-derived fuels. The work comprises generic research and development in the areas of coal beneficiation, hot-gas cleanup, and waste management.

The quality of coal or coal-derived fuel, flue-gas quality, and associated waste materials are all closely interrelated in the ultimate determination of the cost of electricity or thermal energy to industrial and domestic consumers. The program is thus "control systems"-oriented to the extent that it treats coal cleaning, hot-gas stream cleaning, flue-gas cleaning, and waste recovery or disposal as successive, interdependent steps in the utilization of coal.

The Department of Energy's coal cleaning program is oriented toward upgrading the quality of nominally "dirty" coals to levels comparable to No. 6 fuel oil. Coal quality directly affects transportation, capital, environmental control, and operating and maintenance costs in the utilization of coal. Flue-gas cleanup addresses the combined removal of nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulates from the stack gases of conventional combustion units to meet existing and anticipated environmental standards. Gas stream cleanup includes the technologies for removing contaminants during the combustion process or from the process stream prior to its utilization. In addition, advanced technologies are being developed to improve waste handling practices and to recover useful resources from wastes produced in the utilization of coal. Those technologies will be applicable to either new or existing boilers or to power conversion installations.

Developing advanced technology in such areas as coal cleaning, gas stream cleanup, flue-gas cleaning, and waste management imposes requirements that go well beyond the short-range, low-risk criteria that normally govern industrial research investment in a situation where there is no incentive to develop technology that surpasses existing standards. Nevertheless, there can be significant benefits to utilities and to the Nation overall if cheaper, cleaner technologies are developed. This is why the Federal Government initiates longer term, higher risk research and development efforts. The DOE role in this case is to pursue applied research and development through subscale evaluations of qualified technical approaches. The extent of DOE involvement depends on what is needed to establish a firm technological base from which the private sector can confidently pursue final development and commercialization.

Section 6(b)(3) of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) mandated research, development, and demonstration designed "to accelerate the commercial demonstration of environmental control systems for energy technologies pursuant to this Act." Responsibility for this program was transferred to DOE under the Department of Energy Organization Act of 1977 (P.L. 95-91).

The historical goal was to permit, through the actual development of improved coal beneficiation and hot-gas cleanup technologies, the utilization of coal or coal-derived fuels in existing and new industrial and utility installations in an environmentally acceptable and cost-effective manner. Specific objectives are summarized in Table 10-1.

In line with the market-oriented philosophy of this Administration, the current goal is to establish the essential technical base for the same technologies, but to rely on the private sector to commercialize them whenever market conditions justify such action. Specific objectives to accomplish this goal are summarized in Table 10-2.

The current program has been sufficiently restructured for minimum Federal involvement and focused on longer term, high-risk, potentially high-payoff activities, so that there are no efficient alternative programs for achieving the same goals and objectives. No other activities are known to duplicate this program. The Environmental Protection Agency (EPA) retained some research and development programs after the bulk of such efforts was transferred to DOE in fiscal year 1979, but the residual effort aims basically at assimilating data to be used in setting control level standards.

Some short-term, low-risk research in the areas of coal cleaning and flue-gas scrubbing is being conducted by private industry.

Program Results

There has been significant progress toward achieving historical program objectives. The availability and performance targets for flue-gas cleanup were achieved, and the results were made available to private industry. The particulate removal objectives in hot-gas stream cleanup were achieved in cold flow tests, but they remain to be accomplished at operating temperature and pressure.

The objectives of the current program are essentially the same as those of the original program, except in the area of flue-gas cleanup technology. Previous work on flue-gas cleanup concentrated on improving the reliability of lime/limestone scrubbers and the development of advanced systems to reduce sludge problems. In view of advances made by the private sector (spurred in part by the DOE program), it appears that these objectives are attainable without further DOE participation. Thus, the Department has set a new objective for itself: to establish the technology base for the development of systems that combine desulfurization, denitrofication, and particulate removal into one process to reduce capital and operating costs. In addition, coal cleaning was added to this program for better integration into the spectrum of control technologies.

The national benefits of this DOE program are directly related to the importance of coal. As the use of coal increases, the cost of coal-derived energy to U.S. business and industry will become increasingly important to the general economy. Large coal users, such as utilities, and basic metals, chemicals, and refractory industries, which support a major share of our economy, will benefit especially. Direct beneficiaries of the program thus far include a large number of manufacturers of air pollution equipment and 5 to 10 utilities where equipment was demonstrated.

The Nation as a whole will benefit by having a cleaner environment from technologies that produce lower emissions than present standards require. All activities of the program are directed toward the production of energy from coal with the least detriment to the environment, public health, and safety.

The intent of Congress has been met, in that progress achieved under this program has supported greater use of coal in the U.S. economy while simultaneously protecting the environment.

Table 10-1 includes details relating to performance and accomplishments over the fiscal years 1978 to 1981 period. Major accomplishments include the following. In coal cleaning, considerable progress has been made in developing methods for separating pyrite from ash constituents in fine coal. An experimental unit to evaluate the process is scheduled for operation by an independent coal producer under a cost-sharing contract. In a related area, the feasibility of separating fine ash-forming minerals and pyrite from coal in a high-gradient magnetic field also has been shown. Methods for separating magnetic material from fine coal were developed to meet industrial deficiencies in this area.

In flue-gas desulfurization, data from cooperative EPA/DOE evaluations of full-scale forced oxidation with lime/limestone demonstrated 90-percent or better sulfur removal. Tests at TVA's Shawnee Power Plant at Paducah, Kentucky, on adipic acid and forced oxidation indicated improvements in sulfur capture and sludge formation, with a 5- to 10-percent cost reduction. Also, on the basis of these tests, a 90- to 95-percent plant availability was projected because of improved operating conditions. These activities resulted in creating a substantial data base, permitting the private sector to take up the remaining development effort for these technologies and to demonstrate their reliability and availability.

Another program activity focused on application of the lime spray dryer to eastern high-sulfur coals. This technology, potentially the most viable flue-gas desulfurization system for U.S. applications, could be expected to reduce capital and operating costs of a flue-gas scrubbing system by 15 to 25 percent. Initial tests at the process-development unit scale have been very promising.

In hot-gas cleanup, bench-scale tests indicate that the program's initial objectives are attainable, but further testing at the pilot plant level will be needed to validate the technologies at an acceptable scale.

Projected Program Requirements

The fiscal year 1982 funding level for this program is $22.0 million. Efforts will be concentrated on the four cleanup elements of the integrated program with a reasonable chance of achieving the objectives cited in Table 10-2. Testing will be initiated on two advanced simultaneous NO_x and SO_x flue-gas cleanup concepts. Tests and studies will be continued in the gas stream cleanup areas, emphasizing only the most promising particulate and alkali removal concepts for turbine protection. Coal-cleaning efforts will emphasize fine-coal physical cleaning by advanced technologies including froth flotation, high-gradient magnetic separation, and heavy-media cyclone separation. Chemical cleaning research will continue toward a reduction to less than one percent ash and one percent sulfur in the cleaned product. Waste stream efforts will include sample gathering, tests, and studies aimed at developing advanced coal combustion waste management techniques.

The fiscal year 1983 budget request provides for investigating new and advanced technologies to remove sulfur and ash from coal; the continuation of research at a reduced level in electron irradiation, advanced chemical processing, and particulate control to enhance flue-gas cleanup; and completion of efforts to ameliorate alkali and particulate damage to high-temperature turbine blades, as well as completion of the assessment of the most desirable NO_x control techniques.

A 10-percent increase in current funding levels could be expected to modestly advance completion schedules--probably less than 1 year. With a 10-percent decrease, consideration would have to be given to the prospect of eliminating some activities and delaying planned completion dates. It should be noted, however, that this program complements and supports parallel DOE work in coal liquids development, gasification, and--most particularly--coal water slurries, fuel cells, turbine combined cycles, and advanced combustion.

<u>Transitional Requirements</u>

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(11) OIL SHALE (FE)

Because the United States has vast domestic resources of oil shale, convertible potentially into convenient liquid fuel, the development of this resource in an environmentally acceptable manner has assumed great significance.

Oil shale processing technology is subdivided broadly into two approaches, surface- and in-situ retorting. Surface retorting requires conventional mining, crushing the shale to a specific size range (dependent upon the particular process used), and heating the shale to about 900° F to convert the organic material it contains (kerogen) into a synthetic crude oil. This crude oil must be upgraded by treating it with hydrogen to remove impurities, particularly nitrogen, before it can be used as a refinery feed-stock. After retorting, about 80 to 85 percent of the oil shale remains as a solid waste that must be disposed of, representing a massive materials handling requirement as well as a potentially serious environmental control problem.

In-situ technologies differ from surface processes in that they involve breaking up the shale underground in controlled patterns of particle size and permeability distribution and then heating the shale in place to produce oil. In-situ methods avoid the problems associated with surface disposal of spent shale, but potentially pose different environmental control problems that must be addressed. Some in-situ technologies are especially well suited to the particular geologic variations of oil shale deposits, but in general they are targeted for deposits that are less technically and/or economically attractive to conventional mining and surface processing.

Industry research and development is heavily oriented to engineering and hardware design and to testing specific proprietary retort methods. Historically, this work has been based in large part on the scientific data base and the concept development efforts provided by the Federal oil shale research program, including DOE's present program.

Program Objectives

The Department of Energy Organization Act of 1977 (P.L. 95-91) created the Department of Energy, which incorporated the research and development programs of ERDA and the Bureau of Mines into a single oil shale extraction and conversion program. These programs date back to the Synthetic Liquid Fuels Act of 1944 (P.L. 78-290). The present DOE program draws its authority from section 6(b)(3)G of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), which mandated "oil shale research, development, and demonstration of the production of syncrude from oil shale by all promising technologies including in-situ technologies."

The major goal of the Oil Shale Program during the fiscal years 1978 to 1981 period was to accelerate the development of oil shale technology by developing engineering design studies of first-generation surface retort processes; by developing and demonstrating the technical and environmental potential of in-situ oil shale processes applicable to three of the four major types of western shales, leading to commercial development in the 1980's; and by developing a data base and evaluating advanced concepts for long-term (1990-2000) development of more efficient and environmentally benign processes that could increase economic recovery of western resources and make eastern shale resources economically recoverable, too.

The current goal is to concentrate on providing the data base required to develop the more efficient and environmentally benign second- and third-generation processes needed for increased economic recovery of western resources, and--more specifically--to obtain improved generic data on the chemistry and physics of oil shale processing and waste handling (air, water, and solid waste) and on controlled rock fracturing.

The technology-base research includes studies of the chemistry and physics of oil shale retorting, oil shale fragmentation, and new process concepts. Research on environmental protection includes characterization of air, water, and solid waste emissions from various retort processes, because studying these as a function of process operating parameters can help identify improvements in design or control procedures that will reduce the downstream needs for environmental control equipment. This part of the research and development effort also seeks to develop and test improved control procedures for those emissions that cannot be eliminated through improved designs and modified operating parameters. These studies are performed as a combination of DOE laboratory, university, and other contract research projects.

The specific historical and current objectives of the DOE programs are cited in greater detail in Tables 11-1 and 11-2.

No other Federal or state program duplicates the research and development mission related to long-term, high-risk technology-base development for second-generation surface or in-situ extraction of shale oil. Private industry generally restricts research to relatively near-term developmental projects on specific processes; and, in fact, it has little incentive to pursue long-range generic research on oil shale. Industry, nonprofit, and academic institutions are all sources of new ideas, and they often conduct some initial research to support an idea before requesting Federal support for further concept development. If Federal support is not forthcoming, however, such research is usually abandoned. The following are some specific examples:

- Both the Illinois Institute of Technology Research Institute (IITRI) and Texaco/Raytheon conducted specific process-concept research, drawing upon generic radiofrequency research by Colorado State University that had been funded earlier by DOE. Both groups then requested DOE funding for further development. IITRI was funded as a result of competitive selection, and this led to additional funding of the project by Halliburton (an oilfield service company). No further Department funding was awarded to the Texaco/Raytheon research.

- Generic research by DOE on the modified in-situ concept was followed by industry research and development on specific designs (Occidental, Rio Blanco, and Geokinetics). DOE has continued to provide technology-base assistance to all three companies, as well as cost-sharing assistance to Occidental and Geokinetics.

Under the Energy Security Act of 1980 (P.L. 96-294) DOE's Alternative Fuels Program resulted in nonduplicative, complementary engineering-design studies related to some of the processes included in the Oil Shale Program's previous demonstration or design objectives. These studies are the following:

- The Paraho design study for a commercial module (under the Oil Shale Program) was augmented by an Energy Security Act award to extend the design study and evaluate feasibility of a 30,000 barrels-per-day plant based on three such modules. The Paraho process itself is closely related to the gas-combustion process developed earlier with Federal support.

- Geokinetics received an award to evaluate the feasibility of designing a mine so that secondary recovery could be performed in situ after some shale had been removed for surface retorting.

The Synthetic Fuels Corporation (SFC) has authority to cofund and provide loan guarantees for commercial-scale demonstrations and commercial-size plants, but it does not support research. For this reason, complementary oil shale awards were made by the Department to Union and the Oil Shale Corporation (Tosco) under the interim authority of the Energy Security Act.

Some research in mitigating adverse environmental effects is conducted by the Oil Shale Program in cooperation with DOE's Office of Energy Research (OER) and with the Environmental Protection Agency (EPA). EPA has expressed its philosophy that DOE has the lead role in developing environmental control technology and in generating environmental data on new technologies. The OER research is targeted on a series of major environmental issues, such as ecological impacts, health and safety guidelines, data-base development for air and water, and the definition of solid waste problems.

The program has been focused sufficiently on longer term, high-risk, potentially high-payoff activities so that there are no efficient alternatives to it if extensive utilization of oil shale resources is to take place. Current and emerging technologies are economically appropriate for only a small percentage of the 1.8-trillion-barrel western oil shale resource (generally the richest layer near the top of shale deposits). Development of this zone by itself could destroy the potential for later development of the deeper deposits (the majority of which are federally owned). Additionally, using current technologies exclusively would mean that the rate of development would have to be constrained, possibly to as little as 400,000 barrels-per-day, because of the cumulative environmental emissions from multiple plants operating simultaneously.

Present-generation processes have resulted from prior Federal technology-base research and (in most instances) from development and demonstration programs supported by either the Federal Government or by foreign governments. Industry will continue to concentrate on mechanical hardware improvements and scale-up of these relatively "proven" processes. Because the private sector still lacks real commercial experience with these present-day processes and with rich shales, however, it has no great incentive at this point to look beyond them and perform long-term, technology-base research aimed at tapping leaner eastern and western shales. Industry has no incentive to identify potential improvements in environmental control technology either, but will continue to rely on "best available control technology" (BACT).

Program Results

As described in Table 11-1, the fiscal years 1978 to 1981 near-term objectives were substantially met. They involved the design and evaluation of first-generation surface retort modules for potential demonstration and the advancement of in-situ technologies to the point of potential commercial application during the 1980's. At least four industrial projects moved toward potential commercial development, and three of these are represented by current applications to the Synthetic Fuels Corporation for loan and/or price guarantees. A longer term concept-development project on surface hydrogen retorting resulted in licensing of the process for further development by a major oil company for application to eastern shale deposits.

In light of the accomplishments in first-generation technology, it was easy to shift program focus at the end of fiscal year 1981 away from commercial stimulation and back to basic research and development and environmental research--but this time to support development of advanced methods that could increase the useable resource base well beyond the estimated 5 percent that is currently commercially attractive. This is high-risk research; but it has potentially high payoff in the longer term, and the reorientation is in accord with the current Administration's philosophy of allowing market forces to determine choices among energy options and the general pace at which commercialization should take place.

The technology base built by DOE's research and development on shale oil is used directly by the architect/engineering firms responsible for detailed plant designs, as well as by the engineering departments of companies that are developing oil shale processes and must provide specifications to such architect/engineering firms. At present, an estimated 20 to 30 companies are either developing oil shale processes actively or evaluating those that are available for potential licensing. These companies range from large petroleum and mining firms to relatively small technology-development businesses.

This program is also benefiting the Nation as a whole, because shale oil can provide a broad range of transportation fuels and petrochemicals at a future cost that is estimated to be somewhat less than other sources of synthetic liquid fuels. The net result of developing an oil shale industry will be broad, favorable impacts on economic stability and national security (by reducing our dependence on foreign oil), on employment (by virtue of the number of corporations actively involved), and on price inflation (by providing an economically competitive substitute for foreign oil). However, there also will be unfavorable regional impacts--both socioeconomic and environmental--that will be particularly severe and will restrict the ultimate production level of shale oil if all development concentrates on the rich western deposits to which present state-of-the-art technologies are limited.

Potential worker health and safety problems of an oil shale industry are believed to be similar to those of mining and the petroleum or petrochemical industries. The U.S. Bureau of Mines is responsible now for mine safety research, including research applicable to oil shale; and the Mine Safety and Enforcement Administration has additional responsibility in this area. Results of short-term laboratory and animal toxicity studies thus far have been ambiguous, so long-term worker health monitoring will be needed to identify any unusual risks that might be peculiar to exposure to oil shale or to shale oil-related materials. Such studies will be performed by the industrial projects for which DOE has negotiated Defense Production Act of 1950 (P.L. 82-774) agreements (Colony and Union); and those health monitoring data will be made available to the Department for evaluation or other use.

The congressional objectives mandated in the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) and supplemented by specific guidance in subsequent annual authorization and appropriation bills have resulted in an even mix of short- and long-range research, development, and demonstration. The program has emphasized in-situ technologies, but it also has included engineering design and evaluation studies for first-generation surface retorting modules and also research and development on one hydrogen retorting surface concept with particular potential for use with eastern shales. Several processes have reached the point where they are considered ready for further development and/or commercial deployment by industry; but only a small part of the total oil shale resource is presently an economic (or, in many cases, technical) target for these processes. Substantial improvements in the scientific basis for more efficient and environmentally benign process designs or totally new concepts are required if a large percentage of the oil shale resource is to help fill the energy needs of the Nation.

The substantial progress made in the fiscal years 1978 to 1981 period was assisted by industry cost-sharing of the major projects, so that annual costs to DOE were about $29 million to $50 million (including $15 million in fiscal year 1979 specifically to support the surface module studies). The first engineering design study on commercial-scale surface modules, the Paraho study, was completed in December 1981; and when the second study is completed during this fiscal year by Superior, the marketplace (and, possibly, the Synthetic Fuels Corporation) should be able to judge their commercial readiness. The SFC charter (supplemented by the DOE interim program that resulted in Defense Production Act incentive awards to Union and the Oil Shale Corporation) obviates the need for the DOE Oil Shale Program to demonstrate first-generation surface technologies.

Two industrial in-situ oil shale processes (Occidental's vertical modified in-situ process and Geokinetic's horizontal in-situ process) are conducting demonstration tests at a scale that the companies believe will be the basis for commercial decisions in the mid-1980's. Development and demonstration of both were supported during fiscal years 1978 to 1981 by DOE's technology-base research and by cooperative funding. An additional industrial project (Rio Blanco) is conducting pilot-scale tests of an alternative, vertical modified in-situ concept; in that case DOE contributed to the necessary technology base in the areas of retort modeling and interpretation, as well as advanced instrumentation tests. During this same period, the chemistry of modified in-situ retorting was clarified and integrated into a one-dimensional physical model; and advances were made in a broad range of other scientific aspects of in-situ oil shale conversion--including fracturing, geochemistry, and environmental studies. The new findings were described in almost 800 technical papers and publications. Longer range research and development was also supported under contracts on potentially advanced concepts, including the use of radio frequencies and superheated steam in-situ retorting, in-situ fracture and recovery from eastern shales, and surface hydrogen retorting of eastern shales. The latter project led to subsequent industrial licensing for further development. Table 11-1 provides a more complete description of program accomplishments.

Projected Program Requirements

The program budget for fiscal year 1982 is $19.2 million. This is substantially below prior levels because of the change in program focus. A modest level of effort sustained through the 1980's and beyond will support a viable program of generic research on specific problems in the areas of chemistry, physics (particularly process kinetics and explosive rock fracture), and environmental control of air, water, and solid wastes. This level of funding also will enable the program to maintain a core of Government expertise in these areas and fill in some of the present data gaps. At this level, the effort will be restricted primarily to western shales. No support will be provided for evaluating specific advanced process concepts. Table 11-2 provides more detail on anticipated program requirements.

At a 10-percent increase in funding, a modest increase would be possible either in the number of research questions addressed within the above framework or in the rate of progress on a more limited number of projects.

At a 10-percent decrease in funding, ongoing projects within the above framework would be reviewed for viability of further stretchout or priority for termination or both.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(12) UNCONVENTIONAL PETROLEUM TECHNOLOGIES (FE)

Thus far, approximately 121 billion barrels of U.S. petroleum have been produced and consumed--out of a total resource estimated at 490 billion barrels, if heavy oils and tar sands are included. However, it is estimated that only 27 billion barrels of the remaining U.S. oil can be produced by currently available (primary and secondary) recovery procedures. This leaves 342 billion barrels of oil as a target for enhanced oil recovery. Even in the near-term, the application of known and advanced enhanced oil recovery techniques is expected to result in recovery of an additional 18 to 53 billion barrels, so enhanced oil recovery represents one of the most practical methods available for increasing the domestic supply of liquid fuels.

Program Objectives

The petroleum research and development function was originally assigned to the Department of the Interior. It was transferred to the Energy Research and Development Administration (ERDA) upon its creation under the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577); and it was subsequently incorporated into the Department by the Department of Energy Organization Act of 1977 (P.L. 95-91).

Today, the Unconventional Petroleum Technology (UPT) Program comprises the following subprograms: Enhanced Oil Recovery, covering the light oil, heavy oil, and tar sand resources; and Advanced Process Technology, addressing fundamental understanding of basic petroleum science.

The UPT Program includes two interrelated elements: base institutional requirements and focused university research. Included in each are the related technology transfer activities that ensure the timely and effective dissemination of research results.

The UPT Program is largely managed by the Bartlesville (Oklahoma) Energy Technology Center, with support from the Morgantown (West Virginia) and Laramie (Wyoming) Energy Technology Centers and the San Francisco Operations Office. Government scientists and engineers are conducting basic research that will broadly assess the potential of new concepts and provide a better understanding of existing technology. University research conducted under the UPT Program is viewed as a direct extension of Federal research activities. However, it is more narrowly focused on projects suitable for a university environment. Some of the best contributions to UPT science and engineering are expected to continue to come from the universities. High technology facilities and specialized expertise from the national laboratories round out the core capability. The Federal Government, through the UPT Program, is a central data source for much technical information on petroleum extraction, processing, and utilization. This is the basis for the technology transfer function at the Bartlesville Energy Technology Center. Data analysis and interpretation are conducted primarily for the cost-shared and incentive programs. A final important part of the Department of Energy work on enhanced oil recovery is to test new concepts by validating results in the laboratory or (if possible) at the site. Most often, this takes the form of post-test information gathering from extra logging of wells, additional coring, and laboratory support work. This procedure also usually provides an improved analysis of the actual process mechanisms involved.

The principal areas in which new technical advances could contribute to improved liquid recovery are the following:

- Enhanced Oil Recovery (EOR)--On average, only one-third of the oil originally in place in U.S. reservoirs is recovered by conventional techniques. The recovery efficiency can be significantly improved by reducing capillary forces, reducing interfacil tension, and increasing the oil's mobility, but this requires innovative chemical and thermal processes and better definition of the reservoirs themselves.

- Advanced Process Technology (APT)--The need here is to develop pioneering science and engineering to determine the chemical and physical molecular structures of fossil energy liquids (including synthetic fuels), so they can be altered more readily to meet final product specifications.

The basic goal of the Unconventional Petroleum Technology Program always has been to accelerate the development of advanced processes to recover an increasing portion of the U.S. oil in place that cannot be recovered via known recovery techniques--and also to provide technology-base support for private industry initiatives to increase the production and recovery rates of all liquid fossil fuels. The main thrust of the program originally was to gain field experience with a variety of different processes and to carry on the university and in-house laboratory work needed to gain a better understanding of what was occurring in the field. The UPT Program sought to address areas of petroleum technology that were not emphasized in oil industry research and development, primarily because they were high risk and of questionable near-term application.

Today, the situation has changed perceptibly. Oil price deregulation and special tax treatment have stimulated greater field application of known EOR techniques, and the analysis of Department field test results has helped identify knowledge gaps. The current goal of the Federal program is to develop fundamental, long-range, potentially promising extraction technologies that attract limited or no private venture capital because the risks are too high or too unpredictable, or because the payoffs are too far down the road.

The unique expertise national laboratories have derived from certain military and space applications is used, and in-house research is conducted by energy technology centers and selected universities. Specific historical and current objectives are shown in Tables 12-1 and 12-2.

While the current program does not duplicate any known industry activity, it complements the industrial field activities oriented mainly toward lower risk, predictable processes. Much of the recent industrial field activity has resulted from the Tertiary Oil Recovery Incentive Program, which has nearly doubled the number of active projects since it began in 1979. Today, the number of such projects is more than 400. In the small number of cases where very advanced processes are being tested by industry, the Department of Energy is examining the possibility of introducing additional instrumentation and gathering extra data to help improve the understanding of these processes.

No alternative means of achieving this program's purposes are likely to be both efficient and effective. If additional research and development incentives were provided, industry still would tend to focus most of its activity on research and development with a relatively near-term payoff, as is the current practice.

Program Results

Many of the original objectives shown in Table 12-1 concern programs scheduled to be completed in the near future. In general, milestones leading to these objectives have been met on schedule. EOR development has been accelerated through field testing, and the technology has been transferred to industry within budget and time constraints.

The main effort of the original program (started under ERDA) was a series of cost-shared field projects for some of the most promising reservoir/process combinations. Experience with them showed that for many applications EOR is far more complex than was thought originally, so that the technology base needed to be broadened if follow-on concepts were going to be fruitful. This conclusion, combined with the introduction of additional incentives designed to encourage greater field application of earlier technology, resulted in a shift in program emphasis toward the objective of improving the basic understanding and predictability of advanced EOR processes.

Work in Advanced Process Technology has also undergone a major shift over the same 4-year period. New emphasis is being placed on the processing of heavy oils. Efforts have been initiated to solve chemical stability problems in shale oils and to identify issues related to the mixing of crude oils. This latter work is of critical importance to the Strategic Petroleum Reserve Office.

Many private organizations have benefited from UPT Program initiatives. Independent oil companies--which produce almost 50 percent of our domestic oil, but are normally unable to sponsor or support individual research and development programs--use Government-produced data made available through an extensive technology transfer program. For most independent companies, Government-developed technology is the only source of detailed information on advanced EOR. Major producers also make extensive use of UPT Program-developed data and information. Department of Energy cost-shared field tests have been well documented, and their results have received widespread distribution among major and independent producers alike. Universities benefit not only through information exchange, but also from the significant number of UPT-sponsored university research programs. Many state and local governments rely on the UPT Program and staff for data, advice, and information. Finally, the UPT staff provides support to the Federal Government with technical advice and statistics, state-of-the-art assessments, policy formulation, and the development of legislation.

Because unconventional petroleum technologies have the potential of increasing domestic production of liquids (thus reducing U.S. vulnerability to supply shortfalls), the general public also benefits from the program, although in the longer term.

The effect on the national economy of the EOR and APT subprograms to date has been small, primarily because enhanced oil production in the United States is still limited. However, future beneficial effects on the economy, including improvements in international balance of payments, economic stability, and employment, should be substantial. Our reservoirs passed their peak productivity 10 years ago, but as reservoirs in the Middle East and other areas of the world reach that stage in a few years, the demand for advanced EOR technology will sharply increase. There will be new opportunities to export advanced EOR technology or to barter such technology for other concessions.

The environmental, safety, and health impacts of the UPT Program are quite small when compared with other alternatives for liquid fuels. Much of the emphasis is on extracting a higher fraction of the oil from already developed fields, so this does not require the kind of massive surface activity normally associated with the production of synthetic crudes. Work is in progress to develop answers for a number of questions involving freshwater use in EOR, especially in certain areas of the country; but advanced oil recovery technology is generally far more benign than its alternatives.

The objectives of Congress in supporting petroleum research and development have been met. Specific objectives set out for the UPT Program have been addressed in a timely manner, particularly in the program's heavy oil area. UPT has moved forward in the demonstration of down-hole steam generation, and this has stimulated at least two competing designs and a dozen well tests. This supports the Department's objectives to increase exploitation of the heavy oil resource. In direct response to a congressional initiative, work has been initiated on the special problems of upgrading heavy oils. The UPT Program, as the Department's major petroleum activity, has supported the Strategic Petroleum Reserve Office in determining which crude oils can safely be mixed and which cannot. This is significant because stability problems can result if incompatible crudes are mixed.

Significant program accomplishments include the conduct of 28 cost-shared field tests on advanced oil recovery techniques, the initiation of a series of cooperative research projects with Venezuela, and the identification of the specific organic nitrogen compounds which cause instability and upgrading problems in syncrudes. Significant in-house research accomplishments include advanced analytical systems, improved definitions of light oil recovery mechanisms, and new approaches to more efficient recovery of heavy oils. There have been sizeable contributions from many university projects in such areas as steam additives for heavy oil recovery (Stanford), chemical compositions for EOR (Texas, New Mexico, and Minnesota), and the mechanisms of miscible gas flooding (University of Southern California). From the experience gained in the cost-shared field test program, UPT staff were able to assist the Economic Regulatory Administration in the successful enhanced oil recovery incentive plan mentioned previously.

Although the drilling program was never large, it has had a number of outstanding successes, including new design and fabrication technology for bits and a pressure coring system. All of its innovations have been adopted to some extent by industry in the last few years, and these engineering projects have been virtually phased out. Table 12-1 provides additional detail about program accomplishments.

Projected Program Requirements

The fiscal year 1982 budget for this program is $20.2 million. Under the EOR and APT strategies, the minifield tests of 1979 and, to the extent possible, the large prior field tests will be phased out in fiscal year 1982-83. The downhole steam generator work for heavy oils will be completed in fiscal year 1982. The in-house and university advanced research in EOR and APT will continue through 1982 into 1983. All tar sands work will be phased out in fiscal year 1982.

Specific program objectives for fiscal year 1982 and beyond are set forth in Table 12-2. The combined EOR Program for light and heavy oils and tar sands will emphasize advanced research and development in chemical, miscible gas, and thermal processes, both in-house and in selected universities. Data from the cost-shared and incentive pilot field tests will be analyzed. Development work will continue on improvements in the down-hole steam generator, components, and steam additives.

APT will emphasize innovative processes for oil, gas, and shale surface and in-situ applications. Characterization and processing work to upgrade synthetic fuels will continue, and Bartlesville Energy Technology Center will prepare small test quantities of mobility reference fuels.

The current revised annual funding level will provide for substantial completion of the goals and objectives listed in Table 12-2 by the end of fiscal year 1983. Table 12-2 provides additional detail on projected program requirements.

A 10-percent increase in the UPT budget would result in expanding and accelerating enhanced oil recovery research in stimulation by microbial techniques and the effects of additives on steam and carbon dioxide recovery methods. A 10-percent decrease would reduce efforts in the Advanced Process Technology areas of improved analytical processes, synfuels technology, and environmental research.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(13) DOMESTIC ENERGY SUPPLY (FE)

Program Objectives

The Domestic Energy Supply Program, which essentially ended in fiscal year 1981, did not consist of research and development on energy technology. Instead, it was associated with the earlier commercialization activities of DOE, and its intention was to promote the greater availability of domestic coal, shale oil, and oil and gas resources through such nonresearch-and-development activities as incentive programs, the analysis of potential socioeconomic impacts, and planning assistance. The diverse individual components are described below.

Coal. The conversion of coal to synthetic gases and liquids expands the opportunities for using U.S. coal cleanly, and other program analysis units in this report address the technologies involved. This DOE program conducted studies to identify potential markets for the products. In another vein, the nature of the U.S. coal market emphasizes production of coal (especially low-sulfur types well suited for direct combustion) near major markets to minimize economic and environmental costs of long-distance coal transportation. Thus small coal producers can often play a significant role in boosting national consumption, but such producers have traditionally been restricted from expanding production because of difficulties in obtaining adequate long-term financing at reasonable terms. As a result, the DOE Coal Loan Guarantee Program was authorized by Congress to stimulate and accelerate the production of underground low-sulfur coal from such small producers; and, despite the termination of the overall Domestic Energy Supply effort, its ongoing projects will continue with funds already appropriated.

Oil shale. Oil shale is the nearest geologic relative to petroleum in the United States and the cheapest available alternative fuel having a large resource base (see PAU #11, "Oil Shale"). Different extraction and retorting technologies have been under research for about 60 years in the United States, and commercial production has occurred elsewhere in the world for more than a century. Surface retorting technology is ready for commercial module construction.

For several decades, there has been commercial interest in the vast U.S. oil shale resources. However, the limited quality and quantity of the resource available to the private sector (and the high costs of extracting, upgrading, and transporting oil shale to existing markets) have precluded commercial development. At present, there are no commercial-size operations in this country, although there is activity at a number of sites in varying stages, ranging from preliminary design to small-scale retorting operations. A number of U.S. companies now contemplate commercial operations, however; and some--most notably Union and Colony--have begun construction spurred by Government incentives. But two major nontechnological problems remain.

The first is land ownership patterns; the Federal Government controls 80 percent of high-grade resources and has often delayed development. The second is the concentration of the resource in sparsely populated regions, necessitating careful socioeconomic and environmental planning before oil shale can be exploited extensively. The DOE program was initiated to encourage development of U.S. oil shale resources and remove impediments to such development. Its efforts in this case most often took the form of analyses, staff work, support of intergovernmental negotiations, participation in interagency task forces, and advisory-liaison services in connection with individual planning missions.

Oil and Gas. Domestic conventional oil and gas well-drilling activity is presently at record levels. A 100-percent increase in drilling operations has occurred over the past decade, resulting from private-sector response to increasing market prices for fuels. Nevertheless, the enormous resource base connected with enhanced oil recovery, unconventional gas recovery, and frontier area development remains largely untapped. Until rather recently, companies have not rushed to industrialize or commercialize these resources, to a large extent because of uncertainties about the magnitude of the base, the marginal economics involved, and a variety of institutional and environmental barriers. The Federal effort under this program was established originally to expedite the removal of such barriers to extraction. The DOE program led to recommendations for accelerated leasing of Federal lands; incentives to the use of enhanced recovery techniques and other mechanisms are detailed in Table 13-1.

Legislative authority for the Domestic Energy Supply Program can be found in the Federal Energy Administration Act of 1974 (P.L. 93-275) and in the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), which authorized a number of forms of Federal assistance to develop the use of domestic resources by socially and environmentally acceptable means. Subsequently, the Department of Energy Organization Act of 1977 (P.L. 95-91) transferred this authority to the Department of Energy. The program is also based on authority from the Department of Energy Act of 1978--Civilian Applications (P.L. 95-238), which authorized DOE to grant loan guarantees for alternative fuels development and provided authority for assistance to impacted states; section 197(a) of the Natural Gas Policy Act of 1978 (P.L. 95-621); the Alternative Fuels Production Act of 1979 (P.L. 96-126), which provides financial support for development of tar sands and unconventional natural gas, and for processing and upgrading synthetic fuels; and the Energy Security Act (P.L. 96-294), which provides natural gas priorities for agriculture.

The Coal Loan Guarantee Program was authorized by section 102 of the Energy Policy and Conservation Act of 1975 (P.L. 94-163). It authorized the Administrator of the Federal Energy Administration to guarantee loans to small coal producers who otherwise would be unable to obtain adequate financing to develop new low-sulfur underground coal mines. This act was later amended by section 164 of the Energy Conservation and Production Act of 1976 (P.L. 94-385) to include the expansion of existing mines and the reopening of closed mines; and by section 802 of the Powerplant and Industrial Fuel Use Act of 1978 (P.L. 95-620) to include the construction of coal preparation plants.

Program Results

The program met its historical objectives and specific legislative mandate. It promoted the extraction of readily useable domestic energy resources through the development of economic incentive programs and financial support of studies on the potential socioeconomic and environmental impacts from specific energy projects. It is too early to assess this program's effect on the national economy, but there has been significant follow-on industrial investment in activities initially funded through it and related to enhanced oil recovery, synthetic fuels, and the development of underground deposits of coal.

The present Administration is taking a new approach (with a nationwide Program for Economic Recovery intended to improve the climate for technological innovation within the private sector and a concentration of Federal research and development support for long-term, high-risk, high-payoff activities), so the Domestic Energy Supply Program ceased to exist as a distinct entity within DOE during fiscal year 1981. However, the Coal Loan Guarantee Program will continue to support ongoing project commitments and anticipated new activities with funds already appropriated. Parts of the earlier domestic energy supply effort were merged into appropriate research and development undertakings within the fossil energy program.

Those who benefited from the program when it was in existence included state and local governments planning for "boomtown" problems and other possible effects from the development of a synthetic fuels industry, small coal companies, large energy companies considering investment in synthetic fuels, and--to some indeterminate extent--the ordinary citizens who are better off when this country develops its domestic sources of energy.

Special efforts were taken to help local and state governments and Indian groups that might be affected by energy technologies specified in this program to deal with their potential health, safety, environmental, and socioeconomic impacts. In connection with potential oil shale development, the grants made to the States of Colorado, Utah, Kentucky, Tennessee, Alabama, Nevada, and Alaska for the development of planning and management expertise deserve particular mention.

In all, 14 studies were made of the feasibility of producing low- and medium-Btu gas at individual sites; and the program helped to implement five different public laws whose purpose was to provide economic incentives for oil shale and conventional oil and gas development. Table 13-1 lists accomplishments on a year-by-year basis.

Projected Program Requirements

None

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(14) ENHANCED GAS RECOVERY (FE)

Natural gas currently supplies approximately one-quarter of the total energy consumed in the United States; but for about a decade the annual addition to domestic gas reserves from new discoveries has been less than the withdrawals from existing, proved reserves. Although this is expected to change in the short run as a result of increased exploration activity resulting from natural gas price decontrol, all major analytical studies by the petroleum industry, financial institutions, and Government show a long-run decline in conventional gas reserves into the next century. The Nation needs to offset this trend.

Unconventional gas resources are underutilized now, relative to conventional sources, because of substantial economic and technical problems relating to their discovery, flow stimulation, and production. However, if any appreciable part of these enormous resources--estimated at more than 200 times our present annual rate of natural gas consumption--can be produced economically, they will represent a secure source of clean energy that could displace a significant volume of imported oil.

Research and development on Enhanced Gas Recovery (EGR) was begun by the United States in 1967 under an authorization to the Department of the Interior's Bureau of Mines for Project Gas Buggy, an attempt at reservoir enhancement using nuclear explosives. Other explosive enhancement tests conducted by the Department of the Interior in the late 1960's and early 1970's were the forerunners of a broader effort addressing the utilization of western gas sands. With the creation of the Energy Research and Development Administration (ERDA), research and development in enhanced gas recovery was moved into ERDA under section 4 of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577). A subprogram on eastern gas shales was added in 1976. The entire Enhanced Gas Recovery Program was incorporated into the Department of Energy under section 301 of the Department of Energy Organization Act of 1977 (P.L. 95-91); and a subprogram on methane recovery from coalbeds became part of it during the following year.

Program Objectives

The Federal role complements industry efforts in those research and development areas required to achieve full exploitation of domestic resources. The unresolved technical problems are complex. First, there is a need for better reservoir diagnostic tools and interpretation techniques. These would permit satisfactory evaluation of identified reservoirs and provide appropriate data for effective and efficient wellbore fracture designs. Second, controlled and cost-effective wellbore fracturing techniques must be developed and demonstrated in promoting more rapid transport of gas from its rock-formation matrix to the wellbore, where it becomes available for production through the wellhead.

The Department of Energy's Enhanced Gas Recovery Program has consisted of subprograms devoted to the major disparate sources: western gas sands, eastern gas shales, and methane recovery from coalbeds. The Western Gas Sands subprogram is a coordinated, multidisciplinary effort directed at increasing the capability for gas production from the low permeability (tight) gas sandstones of the western and southwestern United States. The Eastern Gas Shales subprogram is a research effort directed toward increasing natural gas production from the Devonian shales of the Appalachian, Illinois, and Michigan Basins of the eastern United States. The Methane Recovery from Coalbeds subprogram has aimed at developing methods of integrating the collection of methane with coalbed extraction and utilization systems, as well as basic research on how such techniques might affect future coal mining operations. Currently, slightly less than 5 percent of U.S. gas is being produced from all these gas sources together, with about nine-tenths of that volume coming from the western tight sands.

The goal of the Enhanced Gas Recovery Program has always been to assist the private sector, through research and development efforts, to achieve full exploitation of the currently estimated 300 trillion cubic feet of unconventional gas resource that is not recoverable with existing or emerging technology*. Specific objectives, presented at some length in Tables 14-1 and 14-2, can be summarized as follows:

- To reduce the general uncertainty about the producing characteristics of reservoirs containing each of the designated unconventional gas resources

- To develop and improve diagnostic and extraction technologies to the point where they are ready for commercial development

- To transfer all useful technical and economic data derived from the program to industry

The principal non-Government party engaged in gas research and development is the Gas Research Institute (GRI), which has its own program on enhanced recovery. GRI's early enhanced gas recovery program was structured like its Department of Energy counterpart; and it often supported additional tests at Department sites using the same contractors. This has now changed. An independent GRI analysis supports the recent National Petroleum Council study in its conclusion that, at present, market price incentives and better technologies are prerequisites to commercial production of unconventional gas resources. GRI recognizes that there is a high potential payoff in eventual production from each research and development dollar, and it projects its 1982 enhanced gas recovery program budget to be about equal to that of the Department of Energy's Enhanced Gas Recovery Program. The Institute also has expressed interest in further increasing its fiscal year 1983 budget to pick up some near-term research being eliminated by the Department, but such a move by the gas industry organization is subject to approval by the Federal Energy Regulatory Commission. At the same time, GRI is developing its own program elements and priorities. It is concentrating

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*The current goal applies only to fiscal year 1982.

on "getting gas into the pipeline as soon as possible," especially from blanket tight sands and coalbed methane. The DOE program, on the other hand, has concentrated on research and development pertaining to the longer term, high-risk lenticular tight sands. Thus, there is no duplication between the GRI efforts and the revised DOE program.

The alternative to the DOE research and development program on enhanced gas recovery is reliance on the private sector to perform the additional development required. Given the ongoing efforts of GRI and others, it is clear that work in the field of enhanced gas recovery will continue and that, as market conditions dictate, the results of the research and development efforts will be put to commercial use.

Program Results

Progress toward the original objectives of the program is on schedule. The present program is clearly following the general congressional mandate to advance the technology for exploiting unconventional gas resources. Geologic work has been completed on the eastern shales and coalbed methane, and the resulting technical information is being transferred to industry. Research and development on diagnostic and extraction technology is on schedule, too.* In fiscal year 1981, the Western Gas Sands subprogram, which previously had emphasized large-scale field stimulation tests, underwent a change in direction with the initiation of the multiwell project. This is a research-oriented field laboratory effort that utilizes highly instrumented, controlled field experiments to obtain comprehensive geologic/reservoir characterization of a tight lenticular sandstone. This is done through drilling, stimulation, and testing of three close-spaced wells. After a year's delay (due to site-selection problems), drilling started during September 1981. A readily accessible data base for gas resources in Devonian shales, tight sands, and coalbeds is being formulated on schedule and is about 50-percent complete. There is intense industrial interest in DOE publications and maps relevant to enhanced gas recovery; more than 8,000 requests for such items were received during calendar year 1980 alone.

The primary beneficiaries of this program are the independent operators and producers. Increases in exploration and production from the resources resulting from EGR research and development also would benefit the drilling and pipeline construction industries. Overall, the Nation will benefit (economically and strategically) as additional gas resources are made available.

The potential production from unconventional gas resources has been confirmed by the National Petroleum Council as recently as 1980. The National Energy Policy Plan in mid-1981 projected unconventional gas resources as contributing anywhere from about 2 to 5 quads of cost-competitive energy to the U.S. economy by the year 2000, depending partly on the pace of technological development and partly on price developments.

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*Massive hydraulic fracturing research is under way with the objective of creating 4,000-foot induced fractures.

A major effort within EGR in the past centered on resource assessment work. Resource assessment of Appalachian Basin Devonian shale has been completed after more than 20,000 feet of Devonian shale cores had been collected from 47 different wells. Western gas sands and methane recovery from coalbeds assessment work is approximately 30-percent complete. In the Devonian shale subprogram, research showed that hydraulic fracturing techniques had a 2-to-1 advantage in recovery efficiency over the more conventional shooting techniques. Work at the underground Nevada Test Site showed that in-situ stresses are the dominant factor in controlling induced fracture orientation.

The tiltmeter was developed under the Western Gas Sands subprogram to measure the orientation of induced fractures, and this instrumentation is already in industrial use. Another instrument under development is the nuclear magnetic resonance logging tool. Development and testing of this device is being closely watched by the oil and gas industry.

The multiwell experiment, designed for comprehensive geologic and engineering studies along with stimulation research, got under way during September 1981. The project, utilizing three close-spaced wells, is located in Garfield County, Colorado (Piceance Basin). The offset-well project, located in Meigs County, Ohio, is near completion. Indications are that its results should help to determine the proper shale-well spacings for large areas of the Appalachian Basin.

Projected Program Requirements

The fiscal year 1982 budget for this program is $11.7 million. This budget provides for the completion of reservoir characterization and stress profile tests in the control well of the western gas sands multiwell project, in which a zone in the first well will be hydraulically fractured and tested. Also, high-resolution seismic evaluation technologies will be evaluated at the multiwell site, and studies of nearby outcrops will be completed. Data from the eastern gas shales offset well project, initiated in fiscal year 1981, will be fully analyzed and evaluated in fiscal year 1982. Results of the project should quantify optimum well spacing in Devonian shale. Also during fiscal year 1982, a complete resource assessment of Devonian shale in the Appalachian Basin will be completed; various extraction methods of recovering methane from deep, unmined multiple coal seams will be evaluated; and field experiments will be completed that are aimed at optimizing stimulation designs for containing induced fractures within coal seams.

The Administration proposes that the Enhanced Gas Recovery Program be terminated at the end of fiscal year 1982.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(15) ALTERNATIVE FUELS PRODUCTION (FE)

"Alternative fuels" in this case includes synthetic liquid fuels and high-, medium-, and low-Btu gas derived from coal, as well as the liquid fuels that come from oil shale. The Department of Energy's role under this program has been to select industrial feasibility studies on alternative fuels projects for Federal support and to reach cooperative agreements with the private sector to share design costs and provide Federal loan guarantees and purchase commitments that facilitate actual synthetic fuels projects. The Department's program preceded activation of the Synthetic Fuels Corporation (SFC).

Program Objectives

The Alternative Fuels Production Program was shaped by three pieces of legislation: the Alternative Fuels Production Act contained in the Interior and Related Agencies Appropriations Act of 1979 (P.L. 96-126), the Supplemental Appropriations and Rescission Act of 1980 (P.L. 96-304), and the Energy Security Act of 1980 (P.L. 96-294). Briefly, the pertinent provisions of these acts are the following.

The Alternative Fuels Production Act established the Energy Security Reserve and appropriated funds to the Department of Energy to establish the Alternative Fuels Production Program. The appropriation included $100 million for project development feasibility studies (with a maximum of $4 million per project), $100 million for cooperative agreements (with a maximum of $25 million per project), $500 million as a reserve for loan guarantees (not to exceed $1.5 billion in total guarantees), and $1.5 billion for purchase commitments or price guarantees.

The Supplemental Appropriations and Rescission Act of 1980 gave DOE interim funding and authority for alternative fuels production, making $3 billion available immediately to fund loan guarantees and purchase agreements under the Defense Production Act of 1950 (P.L. 81-774). An additional $300 million was made available by the Supplemental Appropriations and Rescission Act of 1980 for a second round of feasibility studies and cooperative agreements but was canceled subsequently by the Supplemental Appropriations and Rescission Act of 1981 (P.L. 97-12).

The Energy Security Act established goals for synthetic fuels production. Its many provisions include the authority for formation of the U.S. Synthetic Fuels Corporation, whose charter provides for a range of Federal financial assistance, including loans, loan guarantees, price guarantees, purchase agreements, joint-ventures, and even acquisition and leaseback of synthetic fuels projects.

Historically, the Alternative Fuels Production Program was designed to accelerate the near-term production of synthetic fuels and to help SFC lay groundwork for a synthetic fuels industry in the United States. Feasibility studies and cooperative agreements will be completed by the Department, using existing staff on an as-needed basis.

Specific information about the historical objectives of the Alternative Fuels Production Program is presented in Table 15-1. Achieving these objectives will help the country meet the national production goals established in the Energy Security Act of 500,000 barrels of crude oil equivalent per day by 1987 and 2 million barrels per day by 1992.

No other Government or private-sector activities duplicate this program at present. The Synthetic Fuels Corporation's program is designed to assist projects in securing risk capital and is complementary to the Department's Alternative Fuels Production Program. By legislative mandate, SFC is not allowed to conduct feasibility studies. In many cases, the Department's program has helped industrial sponsors define their projects in sufficient detail to apply to SFC for further financial assistance.

Program Results

The Alternative Fuels Production Program achieved significant success in meeting its assigned objectives. It served as the channel for two Federal loan guarantees totaling $3.25 billion, a minimum purchase agreement for $400 million, and $200 million for feasibility studies and cooperative agreements on more than 100 different projects.

The Alternative Fuels Production Program was funded only in fiscal years 1980 and 1981. Four solicitation documents were issued, and more than 2,000 proposals were evaluated. Twenty-two coal synthetics projects and three oil shale projects were selected for feasibility studies and cooperative agreements; one oil shale project and one coal gasification project were selected for loan guarantees; and one oil shale project was selected for a purchase commitment.

Solicitations issued by DOE under the Alternative Fuels Production Act for proposals of feasibility studies and cooperative agreements for commercial synthetic fuels facilities resulted in the sponsorship of 22 coal-based synthetic fuels projects, representing an eventual outlay of some $107 million. These projects include 10 coal liquids plants (all intended to use indirect liquefaction), with two planning to produce gasoline, seven planning to make methanol, and one, a Fisher-Tropsch or SASOL-like facility, producing a variety of fuels and chemicals. There were also four high-Btu gasification projects and seven low- or medium-Btu gasification projects. Three feasibility studies for oil shale projects, totaling approximately $11 million, also were funded.

Three projects were selected for support under the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) and the Defense Production Act solicitations, which were called for by the Supplemental Appropriations and Rescission Act of 1980. These were Union Oil's Parachute Creek Oil Shale Project in Colorado, Tosco's share of the Tosco/Exxon Colony Oil Shale Project at Parachute Creek, and the American Natural Resources High-Btu Coal Gasification Plant at Beulah, North Dakota.

The direct beneficiaries of the program's funding represent a diverse grouping of organizations, including small business firms holding coal leases in North Dakota, Indian tribes in Montana, large multinational oil firms like Texaco, major chemical companies, and utilities. Most often, however, a substantial amount of the funding flows through these project sponsors to the first-tier contractor teams brought together to develop each project. These have included nearly all the major U.S. architect/engineering firms (for example, Fluor; Davey McKee; Dravo; Stone & Webster; Gilbert; Bechtel; Stearns-Roger; Rust; Ebasco; Lummus; and Kaiser); environmental firms (such as Envirosphere, Radian, Dames & Moore, SRI International, and Woodward Clyde); equipment and process firms (such as Air Products, General Electric, and Westinghouse); and investment bankers (including Kidder-Peabody, Lehman Brothers, Bankers Trust, Dillon-Read, and Morgan Stanley).

Thus far, the direct impact from the Alternative Fuels Production Program on the Nation's economy and overall health, safety, and environment has been insignificant. Only three projects in the program (Union Oil's Parachute Creek Oil Shale project, Tosco and Exxon's Colony Oil Shale project, and American Natural Resources high-Btu gasification project) have been given financial incentives that could lead to plant construction and operation. The rest of the activities funded by the Alternative Fuels Production Program were evaluations, and additional financial incentives (such as those potentially available from the Synthetic Fuels Corporation) probably would be required for them to proceed.

In local areas where synthetic fuels facilities might be built, significant socioeconomic and environmental impacts could occur. In unpopulated areas or areas where only a small population and infrastructure exist, local impacts are likely to be greater. This is because whole new communities will need to be built to accommodate construction and operating labor, additional service workers, and their families. Potential locations for coal and oil shale-based synthetic fuels projects--as well as the associated mining operations--include the Gulf Coast, Appalachia, Alaska, Minnesota, North Dakota, Montana, New Mexico, Wyoming, Illinois, Colorado, Florida, Massachusetts, Maine, and Delaware. Environmental emissions from such facilities will be kept to a minimum by the use of suitable environmental control technologies.

This program has helped achieve the congressional objective of encouraging the near-term production of synthetic fuels. Nearly all of the projects funded by the Department of Energy for feasibility studies and cooperative agreements later applied to the Synthetic Fuels Corporation for financial assistance. In fact, many of the projects whose applications to the Department failed to receive funding were able at least to use materials they developed in response to the Department's solicitation as a basis for subsequent applications to SFC. Thus, the Alternative Fuels Production Program helped to accelerate synthetic fuels projects before the Synthetic Fuels Corporation could become operational.

Specific program accomplishments for fiscal years 1980 and 1981 are reflected in Table 15-1.

Projected Program Requirements

No fiscal year 1982 or fiscal year 1983 funds are budgeted for this program. The feasibility studies and cooperative agreements supported by awards in fiscal years 1980 and 1981 will be completed, with existing staff handling the DOE part of these efforts on an as-needed basis. The American Natural Resources high-Btu gasification project (a loan guarantee funded under the Supplemental Appropriations and Rescission Act of 1980) will be monitored by DOE with existing staff; the two oil shale projects funded under the same legislation will be transferred to SFC.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(16) FEDERAL LEASING (FE)

Federal lands* contain an estimated 85 percent of the Nation's oil and tar sands, 80 percent of its oil shale, 50 percent of its geothermal energy sources, 40 percent of its natural gas and uranium; and 35 percent of its coal. Under the authority of the Department of Energy Organization Act of 1977 (P.L. 95-91), the Department's Federal Leasing Program participated in developing Federal energy mineral leasing policies for all federally owned and administered onshore and offshore oil and gas resources and all onshore coal, geothermal, oil shale, uranium, and tar sand resources. Those policies are applied by the Department of the Interior in terms of the number and frequency of leases issued, the terms and conditions of leases, and the rates of production for maximum economic recovery. While the Department of Energy provided the energy policy context for the Interior Department's implementation responsibilities, no significant advantages were evident for continuing to divide these responsibilities between the two agencies. Therefore, the DOE leasing authorities were restored to the Interior Department effective December 23, 1981. This consolidation of leasing activities will result in more efficient government.

Program Objectives

Sections 302(b), 302(c), and 303(c) (now repealed) of the Department of Energy Organization Act transferred responsibility from the Department of the Interior to the Department of Energy for the development and promulgation of regulations pertaining to alternative bidding systems, diligent development, royalty oil, production rates, and leasing competition. More specifically, section 302(b) transferred responsibilities from the Department of the Interior to DOE for prescribing regulations under the Outer Continental Shelf Lands Act Amendments of 1978 (P.L. 95-372), the Mineral Leasing Act of 1920 (P.L. 66-146), the Minerals Leasing Act for Acquired Lands of 1947 (P.L. 80-382), the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377), the Geothermal Steam Act of 1970 (P.L. 91-581), and the Energy Policy Conservation Act of 1975 (P.L. 94-163). In addition, under section 303 of the Department of Energy Organization Act, the Department was assigned the responsibility for reviewing and either approving or disapproving leasing terms and conditions for the Department of the Interior. Subsequently, the two departments signed a Memorandum of Understanding that recognized DOE's responsibilities to establish energy production forecasts on a biennial schedule.

In establishing the Department of Energy, Congress assumed that the Secretary of Energy would be the principal energy policy official and that the Secretary of the Interior would be the principal natural resource management official for the Federal Government. Because the leasing of Federal

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*Federal lands are referred to also as public lands.

lands for the development of energy and energy-related resources involves both national energy policies and natural resource management, Congress authorized leasing programs for each of these departments.

The principal goal of DOE's Federal Leasing Program was to increase the availability of Federal lands for energy resource development through the leasing of onshore and Outer Continental Shelf (OCS) tracts. This goal, which traditionally has been the Interior Department's responsibility, can continue to be pursued by Interior while it also pursues its goal to provide for and protect the public interest on federally held lands. More detailed and specific historical objectives and accomplishments of the DOE program are summarized in Table 16-1.

Program Results

The specific historical objectives of the DOE program have been met. Since its inception, the DOE Federal Leasing Program has promoted increased leasing to meet production goals and to develop domestic energy resources.

The program has given small, independent, and large operators a greater opportunity to invest in activities leading to increased domestic energy production. This will result in increased employment in the production sector as well as in other manufacturing and servicing sectors of the economy. The Nation's many energy consumers also will benefit from additional energy supplies available at prices lower than the cost of imported oil. However, the greatest beneficial effects from improved leasing policies are of a macroeconomic nature. Expanded domestic energy supply helps to curb inflation and bolster national security. Accelerated leasing during the rest of this decade and the 1990's should lead to earlier exploration and development of domestic mineral reserves, thereby accelerating realization of the positive economic benefits that result from the Government's leasing program.

Apart from the program's obvious stimulus to oil and gas production, the program's success in accelerating coal leasing will contribute to an adequate supply of coal reserves available for utility and industrial coal use and coal for synthetic fuel production. The production of coal-derived synthetic fuels, in turn, will help to ensure an adequate supply of chemical feedstocks. The Nation's agricultural sector benefits in many ways from an increase in domestic energy and chemical production; and the reliability of domestic energy sources encourages all types of industrial expansion and renewal.

Major milestones of specific program accomplishments are shown in Table 16-1.

Projected Program Requirements

Since transfer of this program to the Department of the Interior in fiscal year 1982 had been proposed, no funds for fiscal years 1983-87 were requested by the Department of Energy. With passage of the Fiscal Year 1982 Interior and Related Agencies Appropriations Bill (P.L. 97-100), those leasing programs transferred from the Department of the Interior to the Department of Energy under sections 302(b), 302(c), and 303(c) of the

Department of Energy Organization Act were restored to the Department of the Interior.

Any leasing-related information DOE might need can be obtained through low-level monitoring by appropriate Department officers, using general support funds.

Transitional Requirements

None.

b. Nuclear Energy

<u>OVERVIEW</u> The Department's nuclear energy activities have their origin in the technology programs of the Atomic Energy Commission, under mandates of the Atomic Energy Act of 1954 (P.L. 83-703), passed on through the Energy Research and Development Administration (ERDA). The Department's seven civilian nuclear programs involve two different physical concepts of nuclear reactions--fission and fusion. Both fission and fusion research efforts are being undertaken to permit nuclear energy to compete in the marketplace. The focus of the Department's fission program has concentrated on the development of technologies aimed at improving the reliability, efficiency, and safety of current light water reactors; on developing more advanced forms of reactors; and on treating nuclear wastes. The focus of the Department's fusion program is on basic research that must first demonstrate that fusion as an energy source for the 21st century is both scientifically and technically feasible.

<u>Fission</u>

In the years since the Department of Energy was created, commercial powerplants using nuclear fission as their basic heat source have maintained an almost constant share of the Nation's total generation of electricity--varying between one-eighth and one-ninth of annual U.S. output. Because of the hiatus in the issuance of operational licenses following the Three Mile Island accident in 1979, however, the "supply pipeline" of new plants is now full of additional units on which construction and the installation of equipment are virtually complete. More than 30 additional power reactor systems--all of which should be ready for service within the next 2 years--will increase nuclear generating capacity by more than 50 percent as soon as all are licensed. Thus, before 1985 nearly one-fifth of all electricity generated in the United States is expected to be coming from nuclear fission powerplants.

Even today, nuclear fission powerplants operate in more than half the states. They provide baseload electricity because of their generally low operating and fuel costs, and they have established an outstanding performance record among large-scale energy technologies in the United States in terms of safety and environmental acceptability. Nevertheless, the use of nuclear power has grown at a much slower rate than was envisioned at the time of DOE's establishment; and plans for a large number of future plants have been canceled or postponed in the past few years.

This is unfortunate from the standpoint of national resource security, because nuclear power lessens U.S. reliance on imported oil in more than one way. About 1.5 million barrels per day of petroleum are still being consumed by electricity-generating equipment in this country. Electric utilities also use nearly 2 million barrels per day of oil equivalent in the form of natural gas, which could otherwise substitute readily for imported oil in the residential, commercial, and industrial sectors. In all areas of our economy, nuclear-generated electricity displaces additional oil in various types of end-uses. Electric substitution is already widespread in residential and commercial space heating, especially via highly efficient heat pumps, and in industrial process heating and other activities.

There is high potential for even further electrification, however, and nuclear energy is thus a crucial complement to coal as a domestically abundant primary source for baseload power. Although coal reserves in the United States seem ample, even for the distant future, the companion use of uranium in generating electricity frees coal production and transport capacity for direct industrial combustion, for coal export to maintain stability in world energy markets, and for the use of coal as a base for synthetic fuels and petrochemical substitutes.

In assessing the Department of Energy's past, present, and future role in regard to commercial nuclear power, it is important to note that loss of the momentum that had characterized the nuclear utility program up until the mid-1970's can be ascribed primarily to circumstances that lie outside DOE's traditional areas of responsibility. First, construction of all new generating facilities has slowed down as the rate of growth in demand for electricity has dropped--primarily, in all likelihood, because of the increased prices per kilowatt-hour that end-users must pay (including adjustments for the rising costs of fossil fuels used in the great majority of existing plants that generate electricity). Second, even though nuclear power in most parts of the United States is more economical in the long run than any other large-scale generating system (including coal-fired plants), various institutional factors have discouraged utilities from making the higher initial capital investment that a nuclear plant requires. These institutional barriers include the way most state ratemaking bodies calculate the return on investment permitted to utilities, as well as the increased cost of borrowed capital, represented by high interest rates.

The perception of the Federal Government as an unpredictable factor because of apparent inaction and changing policies also has caused utilities and industry to question their further commitment to nuclear energy. For example, the Federal Government has not yet fulfilled its responsibility to provide timely disposal services for high-level nuclear wastes.

The most significant shift in nuclear policy concerned spent fuel reprocessing and breeder reactor development. In October 1976, President

Ford issued a statement that U.S. reprocessing and recycling of nuclear fuel should be held in abeyance until the adequacy of proliferation safeguards could be demonstrated. In April 1977, President Carter took this policy one step further, deferring indefinitely commercial reprocessing, recycling of spent fuels, and commercialization of the fast breeder reactor. He proposed that the Clinch River Breeder Reactor project--a joint Federal Government, utility, and industry effort--be terminated. Design and component work on the Clinch River Breeder Reactor was continued as a result of congressional action, but the suspension of Nuclear Regulatory Commission (NRC) environmental and safety reviews delayed the project schedule.

Finally, U.S. utilities have been reluctant to pursue nuclear projects or to begin new ones during recent years because of retrofitting required by regulatory changes and because of delays and uncertainties in the licensing and regulatory processes themselves, which have made construction schedules unreliable and the risk of cost overruns great. DOE itself does not issue construction permits or operating licenses. Nor does it regulate plant operations. All of these functions are handled by the independent Nuclear Regulatory Commission. Statutorily, the nuclear energy program within the Department of Energy is the successor to the program carried out by the Energy Research and Development Administration between 1974 and 1977. Under the Energy Reorganization Act of 1974 (P.L. 93-438), the newly created ERDA then assumed nonregulatory Federal responsibilities associated with both the military and the civilian nuclear energy programs that had been directed by the U.S. Atomic Energy Commission (AEC) under mandates of the Atomic Energy Act of 1954 (P.L. 83-703), as amended. This section of this report, however, deals only with the civilian program of DOE.*

In accordance with the National Energy Policy Plan, the Department's civilian nuclear energy effort is not intended to subsidize available technology or the appropriate private sector application of such technology. Rather, it focuses primarily on generic, long-range research and development undertakings that commercial enterprises (or even the industry as a whole) might not pursue on a pure investment basis, but which nevertheless are important to this country's midterm to long-term energy future. The current overriding goal of DOE in regard to nuclear power (as it is in regard to other energy sources) is to enable this power source to compete fairly in the marketplace.

President Reagan clarified this goal in his Nuclear Policy Statement of October 8, 1981, which outlined the policy of the current Administration to correct Government deficiencies and to enable nuclear power to make its essential contribution to our future energy needs. To encourage a healthy

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*The national defense activities of DOE relating to nuclear energy, including development of naval reactors as well as work connected with nuclear weapons, are treated separately in Part D of this report, entitled "Review of Defense Programs." Uranium enrichment activities, which support both military and civilian efforts in nuclear energy on a cost-reimbursable basis, are addressed in PAU #46, "Uranium Enrichment Activities."

nuclear industry, the President announced the following policy objectives and program initiatives:

- The removal of institutional and regulatory impediments constraining the continued deployment of commercial nuclear power reactors

- The continuation of demonstration of breeder reactor technology, including construction and operation of the Clinch River Breeder Reactor

- A lifting of the ban on commercial reprocessing

- Deliberate and swift action to deploy means of storing and disposing of radioactive waste

Details of how the DOE nuclear program has addressed its more specific historical and current objectives are given in the six program analysis unit reports that follow this overview. During the term of DOE's existence, progress in some fields (such as the assessment of uranium resources and the provision of specialized nuclear power systems to the national space program) has met or exceeded all reasonable expectations; but, until this year, some other programs (for example, the breeder and waste disposal demonstrations) moved ahead more slowly, for reasons that had little or nothing to do with technological capability.

At present, all programs are advancing normally. For example, with design of the Clinch River Breeder Reactor now nearly 90 percent complete and the fabrication of long lead-time components well under way, site preparation can begin upon receipt of NRC approval, which is expected during fiscal year 1982, and actual fueling should take place before the turn of the decade.

From the standpoint of the environment, the extent to which DOE has facilitated the safe application of nuclear energy has undoubtedly produced net benefits. Compared to the power sources they replace, nuclear plants release negligible effluents to the atmosphere. Uranium is such a compact fuel form that its use reduces mining requirements substantially (as compared with coal or oil shale); and improved mine-safety standards have virtually eliminated the special problems associated with radon in the excavation of uranium ores. The nuclear fuel cycle, as operated by a well-monitored industry with 25 years of experience, poses no environmental penalty or problem that should be considered unacceptable. Nevertheless, efforts will and should continue to make further environmental protection feasible.

Fusion

The Magnetic Fusion Energy Program is one of the major research efforts that the Department is conducting to develop a new source of energy, especially for central station power. It is envisioned that once the process is developed and shown to be economically feasible, fusion energy could become a major source of electricity for the United States in the 21st century. Other possible applications include production of fissile fuel and synthetic chemical fuels. However, this goal is far too long-range for private investment to provide the resources for the complex, high-technology experiments that are needed to make fusion power a reality. Consequently, as stated in the National Energy Policy Plan, "the Federal Government recognizes a direct responsibility to demonstrate the scientific and engineering feasibility of nuclear fusion."

Fusion is a high-technology field in which the United States exerts world leadership. International cooperation offers the advantages of pooling multidisciplinary expertise as well as significant reductions in technology development costs through cost-sharing. Cooperative efforts are under way with the U.S.S.R., Japan, the European Economic Community, the People's Republic of China, the International Energy Agency, and the International Atomic Energy Agency.

The Magnetic Fusion Energy Program's specific goals encompass three phases: achieving scientific feasibility, demonstrating engineering feasibility, and developing improved reactor concepts. As the first phase nears completion with the upcoming operation of the Tokamak Fusion Test Reactor, the next goal becomes an assessment of fusion's potential based upon the information developed in the second phase. As the fusion program progresses from one phase to another, it will be supporting a continuing effort in generic physics research.

The program has experienced progress in both toroidal and mirror confinement leading to improved performance and a growing convergence of these traditionally separate concepts. The toroidal confinement effort has resulted in such advances as the development of neutral beam injectors at Lawrence Berkeley Laboratory for plasma heating. Temperatures in excess of 70 million degrees have been achieved at the Princeton Large Torus using injectors developed at Oak Ridge National Laboratory (ORNL). Similar temperatures at greater plasma densities have been reached recently in the Poloidal Divertor Experiment, also at Princeton; and increased magnetic field efficiency has been shown in experiments at ORNL. These specific accomplishments greatly enhance the likelihood that the next major device, the Tokamak Fusion Test Reactor, will demonstrate the scientific feasibility of magnetic fusion by the mid-1980's.

Progress with mirror systems includes development of a new thermal barrier concept that offers significant theoretical improvements for reducing heat loss; successful operation of the Tandem Mirror Experiment at Lawrence Livermore National Laboratory that provides evidence for electrostatic reduction of end losses; and development of an expanded tandem mirror experiment presently under construction. A related effort, the Elmo Bumpy Torus Proof-of-Principle Project, provided supporting data for previous theoretical predictions on scaling and radio frequency heating.

In addition to these efforts on toroidal and mirror confinement systems, the fusion program continues to pursue experimental and theoretical studies of fusion plasma needed to predict plasma behavior and perform tests and assessments of alternative confinement concepts. The program also carries out development and technology efforts aimed at providing the engineering and technology capability to design, construct, and operate increasingly larger and more complex fusion experimental facilities.

Major independent scientific reviews conducted in 1978 and 1980 have led to the conclusion that the program is technically ready to initiate an engineering development effort in parallel with the continuing program of physics research. Such activities would, jointly, permit a full assessment of the highest potential of fusion before the turn of the century.

(17) URANIUM RESOURCE ASSESSMENT (NE)

From the very beginnings of nuclear power in this country, it has been assumed that it could and would be a purely domestic energy source. However, Congress was concerned about the secure domestic supply of uranium and thus passed section 161v of the Atomic Energy Act of 1954 (P.L. 83-703), which (as amended) provides that the Department of Energy, "to the extent necessary to assure the maintenance of a viable domestic industry," shall not offer enrichment services for uranium of foreign origin intended for use in a U.S. power reactor. Congress also directed DOE "to survey periodically the conditions of the domestic and world uranium markets," which led to the program of uranium resource assessment.

Program Objectives

The goal of the Department of Energy Uranium Resource Assessment Program is to make an accurate, comprehensive, and consolidated determination of the extent of this country's economical nuclear fuel resource base. To do so (and thus remove uncertainties that could distort planning for the future of nuclear energy in the United States), the Department set the following schedule of activities:

- To develop reliable and timely estimates of U.S. uranium reserves and resources from commercially confidential data supplied voluntarily by industry (primarily drill hole logs) and from data acquired through the National Uranium Resources Evaluation (NURE) Program, to open-file aggregated data reports, and to release estimates annually to the nuclear industry

- To analyze uranium supply, production capability, economics, and market conditions based on surveys of the uranium industry and on conferences with uranium suppliers, and to release estimates annually to the nuclear industry

- To assess the viability of the U.S. uranium-producing industry, based on the above-mentioned surveys and conferences, and release the assessments to the nuclear industry

- To participate in cooperative international efforts to assess the world uranium resource base and to contribute to the publication of country studies and to biennial uranium resource publications of the International Atomic Energy Agency and the Organization for Economic Cooperation and Development's Nuclear Energy Agency

The fiscal year 1978 objectives for the NURE Program were to assess by December 1981 the 272 2-degree National Topographic Map Series quadrangles most likely to contain uranium deposits, and to complete by December 1983 the remaining 349 quadrangles. These objectives were established because of the need then projected for considerable production of uranium before the year 2000; but reduced forecasts of nuclear power demand led to a revision during fiscal year 1979 of the NURE goals as follows: to assess by October 1980 the 116 quadrangles that were deemed most likely to contain uranium deposits, to complete the rest of the 272 high-priority quadrangles by December 1983, and to complete by December 1985 a comprehensive report for the total U.S. uranium resource potential. Forecasts of nuclear power requirements continued to decrease, however; and early in fiscal year 1981 the NURE Program was revised again. The new targets were to assess 162 priority quadrangles by October 1981 and to investigate additional world class sites and intermediate grade resource areas. Subsequently, because of tighter budgets, the additional work on world class and intermediate grade areas was eliminated entirely.

Program Results

By the standards of the original fiscal year 1978 NURE objectives, only about one-quarter of the full quadrangle assessment task has been completed to date. Nevertheless, the objectives assigned most recently to NURE (in the fiscal year 1981 Authorization and Appropriations Acts) have been met fully.

Commercial nuclear power reactors now produce more than 11 percent of all electricity used in the United States, and this share is expected to near 20 percent before 1985. The reactors must be supplied with uranium to operate, and the Department of Energy provides the only industrywide base of resource information that can be used in projecting uranium availability and costs. Such information is vital in developing exploration and production plans, as well as supply and purchasing strategies. Thus, the Uranium Resource Assessment Program conducted by the Department has been of benefit to the Nation as a whole, but most directly in the commercial sector. Indirectly, at least, it ultimately benefits national defense as well.

Since proprietary information provided by industry must be used for these assessments, only the U.S. Government has been trusted to assemble the information into industry reports. Furthermore, these studies examine a much longer time period than industry would generally address. The data and analyses produced in this program represent the sole source of Government assessment of uranium resources, supply, and production.

Within the Federal Government, data from this program are used to plan operations at the gaseous diffusion plants and to plan for additional enrichment capacity (and thus, ultimately, to determine the price of enrichment services). Planning for eventual uranium and plutonium recycle through reprocessing is also affected by basic resource data. The pace of programs for the fast breeder reactor and other advanced systems similarly is related to the availability and cost of natural uranium. And, finally, the future of domestic uranium supply and cost is a consideration in defense planning.

As shown in Table 17-1, the obligations for the Uranium Resource Assessment Program were $67.9 million in fiscal year 1978, $72.9 million in fiscal year 1979, $61.5 million in fiscal year 1980, and $30.5 million in fiscal year 1981. Quadrangles were evaluated on a schedule that met the changing objectives of the NURE Program. Interim and comprehensive assessment reports were published on schedule in June 1979 and October 1980, respectively. Advanced technologies for detecting and assessing uranium resources were developed on schedule, and technical reports regarding this work were published. The Department also assisted four international uranium programs during the 4-year period.

Projected Program Requirements

The appropriation for fiscal year 1982 is $10.0 million, considerably below prior levels because the objectives assigned currently to this program essentially have been attained (see Tables 17-1 and 17-2). In light of this fact, the Administration proposes to terminate this program in fiscal year 1983.

A 10-percent increase in the level of support would accelerate the screening and evaluation of a backlog of data obtained under the NURE Program. Also, information obtained through the portion of the NURE Program on hydrogeochemical and stream sediment reconnaissance work would be made available in open files at an earlier date.

A 10-percent decrease in funding would make it necessary to close out contractor activities in data screening and analysis, in improving the methodology of resource estimation, and in providing input to supply analyses. A slowdown in work on supply analyses would mean that the effort to determine production capability for various demand scenarios would not be completed on schedule.

Transitional Requirements

The Administration proposes to terminate the program in fiscal year 1983. There are no executive or legislative actions required.

(18) CONVENTIONAL REACTOR SYSTEMS (NE)

The Conventional Reactor Systems Program includes the following four efforts, listed with their respective aims:

- o Light Water Reactor (LWR) Systems--A program to develop light water reactor technology that will improve safety and uranium utilization, reduce radiation exposure, and increase plant productivity

- o Three Mile Island (TMI) Activities--A program to acquire important safety data from the Three Mile Island plant, its reactor, and the waste immobilization processes used in its cleanup

- o High-Temperature Reactor (HTR) Program--A program to provide a technology base and information about components and systems of gas-cooled high-temperature reactors that have good potential of leading to economic applications for such reactors

- o Reduced-Enrichment Research and Test Reactor (RERTR) Program--A program to help make research and test reactor fuel less susceptible to illicit diversion of weapons-grade material

Tables 18-1 and 18-2 provide detailed information on the accomplishments, goals, and budgets of each.

Program Objectives

Light Water Reactor Systems. In 1976, the Energy Research and Development Administration decided to end a 5-year hiatus in Government support for research and development in light water reactor technology. At that time, light water reactors in nuclear powerplants were not available for service to the extent that had been anticipated, and it was believed that a variety of generic research and development activities might improve plant availability factors or at least prevent further deterioration.

In 1978, the program's emphasis was then revised to reflect Administration policies--especially those intended to discourage the international proliferation of nuclear weapons material. The highest priority within the revised LWR program was shifted to activities that might improve uranium utilization in light water reactors, a step that could support that Administration's decision to defer the reprocessing of spent fuel indefinitely. At the same time, Federal efforts to improve the general availability factors of nuclear powerplants were reduced considerably because of the Department's position that such activities--if warranted--should be carried out chiefly by the private sector.

In addition, two new objectives for the overall LWR program were added in 1978: to reduce the occupational radiation exposures of LWR plant personnel to levels "as low as reasonably achievable" and to improve LWR safety. Later, in response to Presidential directives resulting from the Kemeny Commission's report on the accident at Three Mile Island, emphasis on both of these efforts was increased.

The LWR program has been reoriented to meet the President's directive to the Secretary of Energy to give immediate priority attention to recommending improvements in the nuclear regulatory and licensing process and to remove unnecessary obstacles to deployment of the current generation of nuclear power reactors. The program is designed to contribute significantly to the resolution of major institutional problems that affect the viability of the LWR industry. The program is responsive to the Nuclear Safety Research, Development, and Demonstration Act of 1980 (P.L. 96-567).

The Department's LWR program will complement and supplement Nuclear Regulatory Commission (NRC) and industry programs. Three alternatives have been considered: reliance on industry alone to carry out the required technology development and demonstration; extensive use of the national laboratories to conduct research and development instead of emphasizing industry participation in DOE-sponsored programs; and limiting the Government's role in light water reactor research and development to that safety work conducted by NRC in specific support of its regulatory responsibilities. None of these alternatives are considered as beneficial as the program under way.

Three Mile Island Activities. The Department of Energy's program of safety research at Three Mile Island is specific in location, but generic in potential application. It is designed to secure data of value to the safety of all nuclear reactors; and it is actually part of a coordinated effort following an agreement signed in March 1980 by the Department of Energy, the Nuclear Regulatory Commission, the Electric Power Research Institute (EPRI), and General Public Utilities (owner of TMI-2). A supplemental budget for fiscal year 1980 was approved for this purpose by Congress, and research began immediately.

The efforts of General Public Utilities are aimed primarily at plant cleanup and recovery. Without delaying that schedule, DOE's and EPRI's work will obtain information that would not normally be obtained from the required cleanup efforts. Specifically, DOE is funding data collection, research and development, and information transfer in the following major areas: the survivability of instrumentation and electrical equipment, behavior of radioactive products, program management, data systems, specimen archiving, and the offsite examination of fuel debris. EPRI has similar responsibilities for gauging the reliability of mechanical and structural components; recharacterizing pressure boundaries on the basis of actual experience; and conducting studies of decontamination and dose reduction associated with the primary coolant system.

In February 1981, DOE expanded its research plan to include two more objectives: to examine reactor and core components, analyze effects of the manner in which any of them failed, and evaluate licensing criteria on the basis of these examinations and analyses; and to conduct research and development pertaining to waste management and the immobilization of abnormal waste products, and develop technology for processing and disposing of these wastes.

The other two conventional reactor programs within DOE (the High-Temperature Reactor Program and the Reduced-Enrichment Research and Test Reactor Program) are both in the process of being terminated.

High-Temperature Reactor Program. Government support for the gas-cooled high-temperature reactor concept dates back to Atomic Energy Commission efforts in the early 1960's and totals nearly $400 million. The program's goal has been to develop a commercial reactor that would generate electricity more efficiently and produce useful energy in temperature ranges comparable to those from fossil-fueled boilers--so that nuclear energy might be used also as a source of process heat, which constitutes a very large share of all energy end-use in the United States.

Counting the investment by private industry, approximately $1.3 billion has been spent over the past 20 years in this country for the development of HTR's; and one small prototype HTR (the 330 megawatt-electric Fort St. Vrain Demonstration Reactor, owned and operated by Public Service of Colorado) is currently operating, although NRC technical concerns kept it below full power until November 1981. Its designers attempted to enter the U.S. commercial power reactor market in the early 1970's and actually accepted orders for 10 electricity-generating plants; but licensing problems, delays in the construction program at Fort St. Vrain, and changing economic conditions led to cancellation of those plants. Since then, the HTR Program has been sustained primarily through Government funding.

For the past several years, no funds have been requested to continue development of the HTR Program. Funding has been reinstated by Congress each year since 1978.

The chief goal of the program in fiscal year 1982 is to select a lead plant and to invite funding for it by the private sector, in an effort to demonstrate the commercial viability of the high-temperature reactor under current circumstances.

Reduced-Enrichment Research and Test Reactor Program. This program was established to develop technology that could provide such reactors with a fuel alternative to highly enriched uranium (HEU), thus minimizing the risk of weapons proliferation. The program was initiated to comply with the Nuclear Non-Proliferation Act of 1978 (P.L. 95-242) and also to reduce requirements for U.S. export of highly enriched uranium.

Complementary activities have been established abroad to assess the compatibility of the proposed U.S. policy action with research reactor operations planned by various nations and to meet proprietary objectives. For the most part, however, these emphasize fuel analysis and testing rather than alternative low-enriched uranium (LEU) fuel developments; so their continuation is contingent upon the actual marketing of reduced-enrichment fuels by the United States or others.

Program Results

Light Water Reactor Systems. The safety research and development portion of the Department's LWR technology program was initiated in fiscal year 1979, focusing then on accident-prevention technology and research. After the accident at Three Mile Island and the numerous investigations in mid-1979, the program was expanded to include cooperative efforts with the Institute of Nuclear Power Operations, to improve plant operations, and to evaluate emergency preparedness. With the light water reactor cancellations in 1980 and 1981, a need was recognized to address institutional problems related to safety; and specific activities in this area were initiated during fiscal year 1981.

In fiscal year 1979, DOE began to review light water reactor operating experience to develop points of concentration and the best way to implement its program. The data needed to resolve generic safety issues were further defined, and cooperative efforts in the area of man-machine interface were undertaken with the Electric Power Research Institute. The fiscal year 1979 studies were completed in fiscal year 1980; and a containment sump emergency testing facility was also completed so that testing could begin as part of a joint DOE/NRC program to resolve the NRC's concerns about the performance of sump equipment. Work on improving generic fire safety of nuclear plants was initiated, and scoping studies were completed on evaluation of control room display systems that would measurably improve operator capability to respond to plant disturbances. Test work was started on containment sump reliability at the test facility.

In fiscal year 1981, major activities included technical assistance to the Institute of Nuclear Power Operations for improving the training of nuclear powerplant personnel; efforts to improve operator performance; characterization of risks from nuclear powerplant operation; emphasis on tasks to improve emergency preparedness; and efforts to reduce radiation exposure to workers during plant operation and maintenance.

The Department's efforts improved the regulatory process by providing a technological basis to permit the following:

- A more realistic relationship among design, operational, and regulatory functions
- Less regulatory emphasis on prescriptive rules, accompanied by greater responsibility and accountability in the industry itself
- Less emphasis on hypothetical and low-probability accidents, but heightened realism in assessing the possible consequences of accidents
- More disciplined definition and monitoring at all levels of protection

The original objective of the uranium utilization portion of the LWR technology program, which has now been narrowed to extended burnup, was to make possible a reduction of 15 percent by the year 1988 and 30 percent or more by the year 2000 in the amount of uranium oxide required to fuel a reactor over its lifetime. This would require LWR fuels that could satisfactorily achieve burnups as high as 50,000 megawatt-days per metric ton (MWd/mt). Implementation of these burnups in power reactors will reduce spent fuel generation by 40 percent and ultimately lead to similar reductions in capacities needed for spent fuel storage and reprocessing.

Ongoing projects representing a cumulative Government investment of more than $50 million have demonstrated that current-design fuel can achieve burnups of over 40,000 MWd/mt. These cost-sharing projects have been conducted in cooperation with 11 utilities, all 5 nuclear fuel suppliers, a utility-sponsored organization, and a large number of European and Japanese organizations. Benefits to consumers of nuclear-generated electricity are now beginning to emerge as utilities increase design burnup for future reloads based on the results from this program. Reloads have recently been ordered at 37,000 MWd/mt as a result of this program, and additional orders at burnups up to 40,000 MWd/mt are expected within the next year.

Another portion of the LWR technology program has focused on developing techniques that could assist industry efforts to meet Federal requirements that radiation exposures be kept "as low as reasonably achievable." This specification is clearly open to varying interpretation, so--to ensure wide adoption--DOE pursued dose reduction techniques that would not diminish plant availability but might even enhance it; and the ultimate target was to reduce average man/rem exposures per plant by 50 percent while observing this criterion. The Department was able to undertake some projects whose cost and generic applicability would have been beyond what a single utility could be expected to undertake. In all, 11 projects were carried out in 4 years; but 3 of these were scoping efforts for which a period of in-reactor demonstration was planned.

Dose reduction projects under way now will be completed; and, if they are adopted by the industry, these alone should permit a 10-percent to 15-percent reduction of radiation exposures. The principal beneficiaries are the maintenance and operating personnel of utilities. Although exposure levels within the current Federal guidelines are not expected to produce any general health problems, the effect of this program has been to increase safety margins.

<u>Three Mile Island Activities</u>. The original objective of the TMI program is being met. Data obtained during plant entries and cleanup are made available generally by means of technical reports, seminars, and a computerized data bank. The continuing TMI program is expected to help evaluate present licensing criteria and develop criteria for the future, to assess and improve the computer models used to analyze the course of consequences of severe accidents, and to improve the design of nuclear powerplants. Thus it could well contribute to restored momentum for the commercial LWR program. By aiding the development of technology to improve the safe operation of such plants and specialized technology for processing and disposing of abnormal waste products, it should have a positive impact on the Nation's health, safety, and environment.

<u>High-Temperature Reactor Program</u>. Although the basic technical objectives of the High-Temperature Reactor Program have not changed significantly, the decline in sales of nuclear powerplants and the increasing cost of fossil fuels required to produce process heat have led to several reassessments of the program--both by the Government and by industry.

During fiscal year 1978, Gas-Cooled Reactor Associates was formed to coordinate utility and user interests in the program and to provide an industry perspective to the Government-funded activities. A Federal program redirection gave new attention to the development of fuels, graphite, and materials for high-temperature applications; but it was evident by late fiscal year 1979 that only a lead project, supported by all program participants, could successfully focus the diverse technology efforts. A combined Government-industry effort identified four potential lead projects (namely, steam cycle/cogeneration, gas turbine, high-temperature process heat (reformer), and a nuclear heat source demonstration reactor). The costs, schedules, potential applications, and readiness for commercial deployment of these options were evaluated in detail during fiscal year 1980; and two of them (the steam cycle/cogeneration and high-temperature process heat reactors) were selected for further study in fiscal year 1981.

Each of the plant options for the high-temperature reactor offers significant environmental benefits. As a producer of electricity, the higher steam temperatures result in a greater conversion efficiency and a lower requirement for cooling water per unit of electrical output than other reactor types. The HTR-gas turbine concept, in combination with dry cooling towers, is well suited to water-short areas of the country. The HTR-process heat concept can provide the high-temperature heat for industrial applications that is normally supplied by burning fossil fuels. This may be particularly significant when it is desirable to locate industrial plants in areas of pristine air quality or in industrialized regions where additional air pollutants are not acceptable.

Reduced-Enrichment Research and Test Reactor Program. Thus far, the Reduced-Enrichment Research and Test Reactor Program has defined the present limits of commercial fuel fabrication technology and established the maximum uranium densities that can be achieved in candidate fuels. The higher the uranium density in the fuel meat, the lower the enrichment required. High-uranium-density test specimens of each of the candidate fuel materials have been fabricated, irradiated, and examined to determine their performance capabilities.

A full core of LEU-fuel has been procured for a performance demonstration in the low-power Ford Nuclear Reactor at the University of Michigan, starting in fiscal year 1982. Participation by all the commercial fabricators of research reactor fuels ensures that the related advances in fuel fabrication technology are likely to be commercialized as quickly as possible. The reactor operator and the program staff at Argonne National Laboratory jointly have studied the specific modifications that would be required to switch that particular reactor to low-enriched uranium, but very few reactor operations have technical staffs capable of analyzing such reactor-specific conversions and revising their own safety analysis report appropriately. Thus, it appears that DOE or some other source of such expertise must provide this service if additional conversions to LEU fuel are to be achieved.

Although there have been several changes in departmental priorities since this program began, its early goals have been met, as shown by the accomplishments listed in Table 18-1. The Department plans to terminate its role in the RERTR program in fiscal year 1983. Activities can be continued if funding is provided by other Federal Government agencies.

Projected Program Requirements

The enacted budget for the Conventional Reactor Systems Program in fiscal year 1982 is $106.9 million.

Light Water Reactor Systems. In fiscal year 1982, the projected program for the LWR safety program will allow continued activities to meet the overall objectives, with emphasis toward resolving the safety-related institutional barriers. To implement the program as a comprehensive national program mandated in the Nuclear Safety Research, Demonstration, and Development Act, the Department organized and convened eight working groups composed of representatives from industry, NRC, DOE laboratories, other government bodies, and foreign programs to further define and implement the program.

DOE's technical activities in regard to light water reactor safety will include the following:

- o Application and continued development of risk methods, including the "levels of protection" approach, the data base, and the source term research and development
- o Expanded cooperative efforts with the Institute of Nuclear Power Operations in operator training
- o Expanded cooperative efforts with utilities to develop control room systems
- o Continued transfer of instrumentation technology developed in the Department's defense programs to the civilian LWR industry
- o Continued efforts to ensure adequate emergency preparedness
- o New efforts to improve public understanding of the key issues associated with nuclear power safety
- o Coordination of national programs in eight key areas

A 10-percent higher funding level for the safety program would allow additional efforts in each of the programs. A 10-percent reduction level would delay the efforts to reduce or eliminate institutional barriers to the effective use of light water reactors.

Part of the ongoing extended burnup projects will be completed, but no new projects will be initiated. In fiscal year 1983, a single fuel design potentially capable of achieving 50,000 MWd/mt will be demonstrated, while terminating the multiple efforts on other designs. A 10-percent increase in the level of support for extended burnup above this very low funding level could not significantly enhance program progress; a much larger increase would be needed for this purpose. A 10-percent decrease in the level of support would necessitate premature cancellation of selected projects.

Following congressional guidance that led to deemphasis of the dose reduction element of LWR research, no future year funding will be required. The fiscal year 1982 funding toward completion of existing contracts is $0.2 million.

Three Mile Island Activities. The fiscal year 1982 enacted funding for TMI activities is appreciably above prior levels because of starting the two new research and development programs: a program to gain early access to the TMI-2 core and inspect it at TMI in an effort to acquire important generic safety data, and a program to conduct research and development on immobilizing unique waste forms. The total cost of the new initiative which will be mounted in fiscal year 1982 is expected to be $75 million, and it is expected to be completed in fiscal year 1985. The data acquisition element of the program is expected to continue in parallel at a level of approximately $10 million per year. A 10-percent increase in the level of support would be used to accelerate the waste management research and development element of the program. A 10-percent decrease would delay examination of the reactor.

High-Temperature Reactor Program. The fiscal year 1982 plan for high-temperature reactors is to concentrate on developing a "project decision package" for a lead plant that consists of the following: HTR program management plan; project management plan; schedule; cost estimates; cost-sharing arrangements; design and technology development plan; safety and licensing plan; site qualification plan; engineering and construction plan; and functional specification/conceptual design.

As part of the legislative actions on the high-temperature reactor fiscal year 1982 budget, Congress stated that future Federal support of the HTR Program would depend on a utility organization expressing an interest in building a lead plant for energy production. This program is to be a cooperative effort with the participating utilities and industries, with the Federal Government providing about 40 percent of the total cost. The documents in the project decision package will provide sufficient information about plant performance, cost, construction schedule, and risk sharing for a utility user to decide whether to proceed. In the absence of a utility user commitment to purchase an HTR lead plant, no Federal support for this program is being requested for fiscal year 1983.

Besides funding for the decision package, the fiscal year 1982 program includes documentation of application studies started last year and technology development tasks on fuels, materials, and plant components for both the steam cycle/cogeneration and high-temperature process heat systems.

Changing the level of support for the program would be reflected in the schedule for the lead plant. A 10-percent increase would provide greater compatibility with the prospective preapplication review by the Nuclear Regulatory Commission. A funding decrease of 10 percent would make it more difficult to match Government-funded design efforts with such a regulatory review according to a schedule favored by the industry involved.

Transitional Requirements

Light Water Reactor Systems. Discontinuation requirements for the LWR program apply mainly to the extended burnup program, whose major projects involve multiyear efforts with commitments to long-term irradiation demonstrations that are under way in commercial power reactors. As some of these projects are cancelled, DOE will have to honor contract commitments to the utilities to monitor the performance of the experimental fuel assemblies, or pay the cost of removing and replacing the assemblies with standard fuel assemblies. As a result, cancellation costs are estimated to be roughly 50 percent of the projected costs to complete the projects.

Three Mile Island Activities. If the two new initiatives for the TMI program do not start in fiscal year 1982, there would be no special discontinuation requirement for them. If the existing effort in data acquisition were to be halted, however, an orderly termination would require several million dollars to terminate ongoing contracts and goods and services on order.

High-Temperature Reactor Program. The HTR Program is funded on an annual basis and now has no long-term commitments (that is, international agreements or facilities under construction).

Reduced-Enrichment Research and Test Reactor Program. Discontinuation of the RERTR Program by the Department may require the United States to honor some bilateral agreements; however, termination costs are not expected to be significant.

(19) REMEDIAL ACTIONS (NE and DP)

Program Objectives

The purpose of the Department of Energy's Remedial Action Program is to prevent radioactively contaminated facilities, once they are no longer being used, from becoming a health, safety, or environmental hazard. The program involves the decontaminating and decommissioning of surplus facilities, associated technology development, and particular remedial action efforts such as those associated with former processing sites and inactive uranium mill tailings sites.

Long before the Manhattan Project, radioactive source materials were mined, concentrated, and distributed in commerce without concern about the potential health impacts of radiological exposure. With the establishment of the Manhattan Project during World War II and its quest for large stockpiles of pure uranium, the full force of industry was applied to the processing of naturally radioactive ores. Unique source minerals having a high radioactive content were mined or imported and then were processed to extract uranium or thorium. The residues (sometimes containing concentrations of natural radioactive materials) were disposed of like any other mineral extraction waste. On the other hand, the processes that produced radioactive isotopes as by-products from fission or neutron activation were confined to certain discrete Government-owned reservations. Hence, the radiological contamination that remained from the early Manhattan Engineer District or Atomic Energy Commission operations in private industrial plants or laboratories was primarily from source material.

The Atomic Energy Act of 1954 (P.L. 83-703) made possible the expansion of nuclear programs through the licensing of commercial industrial concerns to possess and transfer source and by-product materials. Under license, the disposition of radioactively contaminated materials and sites became a financial responsibility of the licensee. The policies of the Atomic Energy Commission included the disposal of waste from commercial sources in commercial burial grounds. Many of the processes that supported the Atomic Energy Commission's research and defense activities--processes such as the milling and conversion of source materials, fabrication of reactor cores, and the reprocessing of selected irradiated fuels--also were contracted to licensed industrial firms. As a result, many former Government operations were transferred to contracted facilities.

In the late 1960's, the potential health significance of exposure to radioactive source materials was reassessed in light of data correlating miner exposure to radon gas with the incidence of lung cancer. Several practices making secondary use of uranium tailings also were discovered to have the potential of delivering excessive exposure to individuals. The most serious was the use of uranium mill tailings in the construction of buildings in Grand Junction, Colorado. As a matter of "compassionate responsibility," Congress, under P.L. 92-314, authorized the Atomic Energy Commission to conduct remedial actions to remove tailings in cases where they were found to cause exposure above guidelines set by the Surgeon General. Approximately 740 structures were found to have contamination above the limits. The Grand Junction Remedial Action Program has been under way since 1972 and is now about half complete.

At the same time, studies were begun to identify any other instances where uncontrolled accumulations of source material residues not under license control could cause exposure to individuals or contaminate property above levels considered acceptable for unrestricted use. Two programs resulted from this effort--one to identify and survey industrial plants or storage areas formerly used in the operations of the Manhattan Engineer District or the Atomic Energy Commission before licensing was required, and the other to identify the radiological character of tailing piles in inactive mills that had once produced uranium for Government programs. In both cases, a number of sites were identified that had sufficient potential for producing exposure to people or to the environment to warrant consideration of further stabilization or decontamination. In some cases, natural or man-produced displacement of materials had contaminated other properties in the vicinity, and these were assessed also.

Two programs evolved: the Formerly Utilized Sites Remedial Action Program addresses formerly owned or contracted sites of Manhattan Engineer District or early Atomic Energy Commission operations that were released for unrestricted use but contain contamination above current guidelines; and the Uranium Mill Tailings Remedial Action Program addresses 24 specifically designated inactive uranium mill tailings sites. The latter program was authorized by Congress with the passage of the Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604).

AEC shut down many of its defense production facilities in the early 1960's, and many of its other research and test facilities have been designated as surplus. These were located mostly on large Government-owned sites such as Hanford, Oak Ridge, Savannah River, and Idaho Falls; but additional facilities were on leased private sites or in private industrial plants operated under contract. The number of contaminated sites that require continuing surveillance and maintenance to prevent them from becoming a hazard is actually growing because more sites are being identified than can be decommissioned by the program. The current inventory lists more than 120 different projects to decommission and decontaminate--a total of some 500 distinct facilities. At least 100 more contaminated facilities remain to be officially declared surplus. The facilities and real property involved are restricted from other use because of the radioactive contamination.

All current and former licensees of nuclear facilities are committed under their licenses to maintain resources to decontaminate their facilities (to meet Nuclear Regulatory Commission Standards) prior to license termination. There have been instances where these resources proved inadequate, and still more instances where the sites have been converted from an operating license to a "possession only" license to cover nuclear material inventory. In the latter case, the site remains restricted--and thus committed as an interim storage site for the contaminated nuclear materials. For example, of the 10 power demonstration and test reactors that have been shut down, only 2 were completely decontaminated and dismantled; the other 8 remain entombed or mothballed, pending future disposition.

Because DOE has the capability of performing radiological surveys and remedial actions, many situations of radiological contamination from past operations that were not associated with nuclear programs have been referred to the Department for assistance. States and such Federal agencies as the Environmental Protection Agency and the Nuclear Regulatory Commission have requested help in the surveying and characterizing of contamination. In the case of "vicinity properties" at Edgemont, South Dakota, the Department has been asked to implement cleanup undertaken initially by the Nuclear Regulatory Commission. In some cases, it appears that the Department is considered the responsible agency of the Federal Government for any situation having even remote Federal involvement. The Department has been responsive to such requests whenever adequate authority has existed and funding resources have been available.

Since DOE was established, the specific objectives of the Remedial Action Program have been the following:

- To reduce and eventually to eliminate the large inventory of contaminated facilities declared surplus prior to 1976 and to keep current in decommissioning post-1976 facilities on a "decontaminating and decommissioning as you go" basis

- To implement remedial actions at designated inactive uranium mill tailings sites under the Uranium Mill Tailings Radiation Control Act

- To continue projects under P.L. 92-314, Appendix C, as amended, to remove uranium ore tailings from structures at Grand Junction, Colorado

- To implement remedial actions at sites formerly utilized by the Manhattan Engineer District or the Atomic Energy Commission that have radiological contamination above current guidelines for unrestricted use

- To arrange the transfer of technology arising from decontaminating and decomissioning projects and specific research and development programs as appropriate

The program emphasizes state, local, and public participation in decisions, based on needs to protect the public health and environment. Standards used are those promulgated by the Environmental Protection Agency and approved by the Nuclear Regulatory Commission, as well as appropriate Department of Energy and Nuclear Regulatory Commission regulations. Locations affected by the programs are spread throughout the United States and include military as well as civilian sites. A remedial action may be to acquire the site and control contamination, to ensure stabilization-in-place, or to remove material to some other disposal site.

Program Results

Program funding for fiscal years 1978 to 1981 is summarized in Table 19-1. Funds are provided in the budget of the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness for site identification, radiological survey, and certification that remedial actions have been completed; the radiological assessment program covers private and public facilities used in past nuclear operations conducted for or by the Federal Government, and it includes sites where the Department is responsible for any remedial action. The Assistant Secretary for Nuclear Energy plans and conducts cleanup operations at sites designated for remedial actions by the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness.

Radiological surveys and record investigations have been made at more than 126 sites formerly used by the Manhattan Engineer District and the Atomic Energy Commission. Based on this work, remedial actions are definitely needed at 21 sites and are probably needed at 14 other sites. Remedial actions have been completed at the Kellex site in New Jersey, partially completed at Middlesex, New Jersey, and initiated at Niagara Falls, New York. In Grand Junction, remedial actions have been completed at more than 400 of the 740 properties. In addition, all surplus facilities are being maintained in a safe condition. Two surplus facilities have been decommissioned, and work is under way on 11 other facilities; but the backlog of 500 contaminated surplus facilities has not been reduced significantly because of funding limitations.

In the Uranium Mill Tailings Remedial Action Program, plans and preparations are under way for the 24 designated inactive uranium mill tailing sites and are well advanced for 4 sites of highest priority. Cooperative agreements have been completed with the States of Pennsylvania and Utah, and agreements with Colorado and the Navajo Nation are being negotiated. Alternative disposal sites have been identified, and concept plans have been prepared for remedial actions at 3 of the sites. Appraisal of the Canonsburg processing site is complete, and DOE is ready to proceed with acquisition. Several public meetings have been held concerning each of these sites, and environmental impact statements for 2 of them are being prepared. Site characterization data have been obtained for all 24 sites, and reported for 6 of these.

The Assistant Secretary for Nuclear Energy also funds and manages the subprograms covering surplus commercial facilities; and the Assistant Secretary for Defense Programs provides funds and management for surplus defense facilities. The Richland Operations Office integrates the field implementation of the surplus facilities program that is funded by both these Assistant Secretaries. The surplus facilities management program is paced by the availability of funding, with highest priority given to maintaining adequate control of radiological exposure and contamination and the implementation of the most urgent decontamination and decommissioning projects.

The remedial actions that have been completed through 1981 in Grand Junction, Colorado, have reduced exposures to below the Surgeon General's guidelines in most cases, and occupying these properties now entails no significant health risk. Similarly, the 32 properties that have been cleaned up at Middlesex, New Jersey, and property at the former Kellex site in Jersey City are no longer potential health risks. One property has been cleaned up at Salt Lake City under the Uranium Mill Tailings subprogram, with similar beneficial health impacts.

Radionuclide migration through air, water, soil, and ecosystems could have potentially important effects. Assessment of the progress made by various programs toward meeting congressional objectives is noted in Tables 19-1 and 19-2.

Projected Program Requirements

Cleanup will be conducted using appropriate standards, including operational standards of the Department of Energy or the Nuclear Regulatory Commission, or standards promulgated by the Environmental Protection Agency. Cleanup will be conducted in accordance with congressionally authorized programs. Under present conditions, however, authorized cleanup tends to be performed first on privately owned offsite properties and only on an interim basis at the processing sites, with a monitoring program required pending final disposal of the waste.

An increase in funding would allow for faster cleanup of designated sites and lower total costs for project completion. Conversely, decreased funding would stretch out schedules, raise final costs, and require prolonged monitoring programs.

Transitional Requirements

The Remedial Action Program is required for continued protection of the environment and public health, and for disposition of radiologically contaminated real properties. Discontinuation of funding for the surveillance and maintenance part of this program would terminate these public health activities.

Discontinuing Manhattan Engineer District/Atomic Energy Commission remedial actions at the end of fiscal year 1982 would require that ongoing contractor activities be terminated. Maintenance and surveillance of the DOE property at Middlesex, New Jersey, would be required thereafter. No new legislation would be required pertaining to this subprogram. Many private properties designated as contaminated would be left in that condition, with adverse effects on their owners and potentially on the Federal nuclear programs.

If the commercial surplus facilities decontamination and decommissioning activities were discontinued at the end of fiscal year 1982, ongoing contractor activities would take about 6 months to terminate during fiscal year 1983. Maintenance and surveillance of the DOE surplus facilities and defense-related activities thereafter would be required.

If the Grand Junction remedial actions program were terminated, continued monitoring of residences would be required as a condition of the agreement with the State of Colorado.

If funding for the uranium mill tailings remedial actions were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(20) BREEDER REACTOR SYSTEMS (NE)

The Department of Energy's efforts to advance the technology of breeder reactor systems include three programs:

- Liquid Metal Fast Breeder Reactor (LMFBR)--A program to conduct the research, development, and demonstration needed to advance this means of dramatically multiplying the useful energy content of U.S. uranium reserves

- Fuel Cycle Development (FCD)--A program to develop technology for reprocessing spent fuel from fast and thermal reactors, primarily as a source of plutonium for the LMFBR

- Water-Cooled Breeder (WCB)--A program to develop technology for significantly improving nuclear fuel utilization in water-cooled reactors

A fourth program was terminated during fiscal year 1981:

- Gas-Cooled Fast Reactor (GCFR)--A program to develop gas-cooled reactor technology as a possible backup to the LMFBR

Program Objectives

Liquid Metal Fast Breeder Reactor. The light water reactors (LWR's) in common use today extract only about 1 percent of the potential energy from mined uranium. Our uranium resources are finite, and fuel costs will increase as more costly uranium deposits must be tapped. Production of fuel for LWR's has created vast stores of already mined and processed, but "depleted," uranium--the residue of the enrichment process. When this depleted uranium is used in the fast breeder reactor fuel cycle as a fertile material which is transformed into fissile plutonium during power reactor operation, the result can be an increase by a factor of about 60 of energy production from the uranium mined. Thus, breeding is needed to realize the full potential benefits of our considerable domestic uranium resources; and the aim of the Liquid Metal Fast Breeder Reactor Program is to ensure that this energy option is developed in a safe, economical, and environmentally acceptable manner within a suitable time period. Once the economics, safety, and reliability of LMFBR systems are confirmed, the free market must then decide whether and when they should be commercialized in this country--both for service here and as an export product to compete with other nations that already have advanced LMFBR programs for a fair share of the world market as it develops.

As was the case with the earlier, successful development of light water reactors for commercial power production, the U.S. LMFBR Program has been structured from its inception in two parts: design, construction, and operation of LMFBR plants in progressively larger sizes; and conduct of a fundamental research and development program to advance breeder technology while also supporting plant projects

Two LMFBR plants are presently operating in the United States. The Experimental Breeder Reactor-II, a 20-megawatt-electric plant located near Idaho Falls, Idaho, has been operating since 1963 as a test reactor--providing invaluable performance and operating data. The other is the Fast Flux Test Facility (FFTF), a 400-megawatt-thermal (equivalent to 133-megawatt-electric) test reactor near Richland, Washington, which began operation in 1980. The FFTF is designed specifically for developing and testing fuels and liquid metal components for fast breeder reactors.

The U.S. LMFBR Program has reached a stage where an integrated demonstration of its technology on a large engineering scale is required to prove its reliability as a commercial energy producer. For this reason, the next logical step is an intermediate-sized system--the 375-megawatt-electric Clinch River Breeder Reactor Plant (CRBRP). The plant's design is nearly 90 percent complete; and $600 million of equipment is on order or has been delivered. Preparation for construction of the plant, which is to be located near Oak Ridge, Tennessee, is expected to begin during the current fiscal year. Licensing efforts have been reinitiated now that the national policy debate on the project has been resolved and agreement has been reached between the current Administration and Congress on the desirability of proceeding. This plant is now slated to be in place and to achieve criticality by the late 1980's.

As the next step, DOE already is engaged in advanced conceptual design and institutional planning for a 1,000-megawatt-electric large developmental plant and intends to complete planning with industry for this plant by January 1983. Pressures to reduce Federal expenditures on energy development and production make it likely that this follow-on plant will not be a predominantly Government undertaking. Hence, innovative financial and institutional arrangements are being examined with the objective of maximizing participation by utilities and the nuclear industry. The information resulting from the large developmental plant should provide all the data needed by industry to make a clearcut decision about commercial introduction of the LMFBR. Meanwhile, the LMFBR Program also is conducting development and testing associated with safety physics, fuels, materials, and components. Portions of this effort are expected to assist the Nuclear Regulatory Commission in its task of licensing LMFBR's.

Delays in the LMFBR Program can be traced to the fact that the previous Administration had assigned the Department of Energy a more limited objective--namely, to conduct research and development and merely to maintain LMFBR technology in a state of readiness pending a possible future decision for commercialization. In contrast, the present Administration contends that industry cannot make a firm commitment to commercialize the LMFBR until the Government has reduced uncertainties about its technology and economic potential to a level more consistent with normal commerical ventures. Tables 20-1 and 20-2 compare DOE's successive objectives and the degree to which each set has been or is being attained.

Although several foreign countries have LMFBR programs that are now ahead of the U.S. program in scaled-up demonstrations, it is problematical whether their present designs could meet the stringent U.S. safety and environmental requirements. Even if they could be licensed, the use of foreign LMFBR's in the United States would broaden the scope of our dependence on foreign energy suppliers and reduce one possible avenue for increasing our own exports so as to maintain a satisfactory trade balance.

Fuel Cycle Development. Although the emphasis of the Fuel Cycle Development Program of the Department until recently was on breeder development, it was derived from a program initiated in fiscal year 1975 to remedy technical problems that then precluded commercialization of LWR spent-fuel reprocessing. The purpose of reprocessing spent fuel from nuclear power reactors is to recover material (both uranium and plutonium) for recycling in fuel, and at the same time to separate high-level radioactive wastes for ultimate disposal. The program objectives are to develop and demonstrate fuel reprocessing technology (for both light water and breeder reactor fuels) that will reduce occupational exposure, improve environmental protection, increase operational safety and reliability, maintain acceptable economics, enhance safeguards, and minimize proliferation risks.

To aid in meeting these objectives, a concept termed REMOTEX is being developed. REMOTEX design philosophy seeks to isolate all process and maintenance operations from direct human contact, using equipment components that are both operable and completely maintainable by remote handling devices such as electromechanical servomanipulators. If direct access to radioactive materials is totally precluded, occupational exposures can be reduced, proliferation risks can be minimized, and radioactive effluents can be contained more easily. By eliminating the need to decontaminate areas prior to maintenance, REMOTEX could also decrease downtime for a reprocessing plant and thus improve its availability, reliability, and overall economics. An extensive program has been under way for several years to investigate the feasibility of the REMOTEX concept by developing and testing advanced servomanipulators, improved instrumentation and control systems, and modularized, remotely maintainable process equipment. Table 20-1 lists a variety of equipment items that have already been fabricated, and other key components are currently being designed. An Integrated Equipment Test Facility, now under construction, will contain nonradioactive component testing activities. Beginning in 1982, integrated operation of the head-end component and support systems will be demonstrated.

Conceptual design has been completed on a Hot Experimental Facility (HEF) which is envisioned as a plant of reasonable scale where advanced fuel reprocessing technology can be demonstrated. Alternatives to a stand-alone facility are being investigated, including a head-end facility in addition to an existing facility. During the past 4 years, the fuel cycle program also has studied alternative fuel cycle technologies. The detailed historical and current objectives are shown in Tables 20-1 and 20-2.

Water-Cooled Breeder. The background and status of the Water-Cooled Breeder Program is quite different from the LMFBR Program. Its objective is to develop a method of utilizing light water reactors similar to existing designs to breed fissile material (uranium-233) from thorium, an element distinct from uranium.

In the early 1960's, the Bettis Atomic Power Laboratory, under the technical direction of the Division of Naval Reactors, determined that it might be possible to develop a practical self-sustaining breeder that was cooled and moderated with ordinary (light) water and fueled with uranium-233 and thorium. In 1965, the light water breeder reactor (LWBR) effort was initiated to develop and demonstrate the technology; and a light water breeder reactor core rated at 60 megawatts-electric now has operated satisfactorily for more than 4 years in the Shippingport Atomic Power Station, which supplies power to the Duquesne Light Company power distribution grid. This core is highly instrumented to provide technical data during operation, and its three central fuel modules are designed to simulate modules typical of those that can be used in a large central station reactor plant.

The original lifetime objective of the Shippingport light water breeder core was 15,000 effective full power hours (EFPH) while breeding. To date, this has been exceeded by more than 50 percent. More than 24,000 EFPH have been accumulated, and more than 1.4 billion net kilowatt-hours of electrical energy have been generated. A post-operation examination of the core is planned and is expected to confirm that breeding actually has taken place (that is, that the total amount of fissile material within the core has increased during operation).

Since September 1980 (when the Shippingport LWBR core reached 18,000 EFPH), it has been operated at 80 percent of its thermal rating. Based on present nuclear physics and reactor engineering calculations, as well as on test data, the core is capable of operating to 32,500 EFPH and possibly beyond, although further reductions in power level would be necessary.

Development, construction, and operation of the light water breeder core has produced a wealth of technical information. In addition, substantial technical advances have been made since the Shippingport breeder core was designed and built in the 1960's and early 1970's. To extrapolate from this experience and to develop and disseminate technical information to help U.S. industry decide if, when, and how LWBR technology might be applied to its own programs, the advanced water breeder applications subprogram was established in 1976. Its main objectives are to translate the implications of light water breeder reactor technology to commercial scale; to improve breeding performance beyond that in the Shippingport core; to develop prebreeder concepts needed to start up light water breeders; and to disseminate this technical information to industry.

As with the LMFBR, a light water breeder cycle presupposes the existence of reprocessing facilities. There has been far less experience with fabricating fuel elements containing U-233 than with those enriched with U-235; and the process chemistry for separating reuseable material from waste products in spent LWBR fuel has not been developed beyond laboratory scale. Nevertheless, the Department of Energy has sponsored developmental efforts along these lines (see Tables 20-1 and 20-2).

Gas-Cooled Fast Reactor. This program was a relatively low-level effort, pursued as a backup to the liquid metal fast breeder reactor. The GCFR would have the same role in the Nation's energy economy as the LMFBR and would operate on the same fuel cycle. Interest in the GCFR was motivated by its potential for higher breeding ratios and lower capital costs than the LMFBR. The program was an incremental effort which drew heavily on the helium system and component development work associated with the gas-cooled, high-temperature reactor. Because it used metal-clad fuel, it could profit from and use much of the base research and development effort associated with LMFBR fuel development and core design.

Government and utility interest in the gas-cooled fast reactor concept proceeded at a low funding level throughout the 1960's and early 1970's. Then, in the mid-1970's, increased Government and utility interest in it led to a series of studies concerning the status of the technology, feasibility, safety, requirements for future development, and possible routes to commercialization. A partnership was established between the Energy Research and Development Administration and utilities acting through a cooperative group, the Helium Breeder Associates. Foreign governments and utilities agreed to share development costs and participate in the construction of a demonstration plant. The Southwest Public Service utility company offered a site for the demonstration plant and pledged $100 million toward its construction.

Safety research and technology development activities were conducted by national laboratories. A reference plant design was selected, a conceptual design was completed in 1980, and program plans were prepared for the development of all major components and systems.

The construction of the Core Flow Test Loop, a large helium test loop at Oak Ridge National Laboratory, began in 1978 and was scheduled for completion in 1981. The conceptual design of a gas reactor in-pile test loop, to be inserted in the Transient Reactor Test Facility (TREAT) reactor for transient testing of GCFR fuel was completed by the Edgertown, Germeshausen, and Grier (EG&G) Idaho in 1980.

In its budget for fiscal year 1981, however, the Department proposed terminating the GCFR Program and requested no funds for it. The LMFBR had advanced to a point where it was determined that an alternative technology was no longer necessary, and the GCFR offered no advantages over the LMFBR in terms of proliferation resistance. Attempts by the utility organizations to restore fiscal year 1981 funding in Congress failed, and all program activities were terminated by the end of fiscal year 1981. The Core Flow Test Loop has been turned over to the high-temperature reactor program for testing of reactor components.

Program Results

Liquid Metal Fast Breeder Reactor. The Clinch River Breeder Reactor Plant was authorized initially more than a decade ago in the Atomic Energy Commission appropriation/authorization (P.L. 91-273). Construction activities for the CRBRP were not initiated in 1976 as previously planned because the previous Administration modified earlier policy. The resulting stretch-out in schedule increased the total estimated cost of the plant, but the continuation of funding permitted design and procurement activities to continue. The design work and procurement activities met the required technical specifications. The status of CRBRP design and procurement by fiscal year is indicated in Table 20-1.

The objective of completing a conceptual design for a large developmental plant was met. The conceptual design, containing a significant amount of detail, met all required technical specifications and was produced within the funding allocation. The final report was delivered on schedule to Congress on March 31, 1981, and advanced conceptual design and institutional planning with the utilities to implement the large developmental plant began immediately thereafter.

The research and development program met its assigned objective of maintaining the LMFBR Program in a state of readiness. LMFBR technology was advanced in the areas of components, safety, physics, fuels, and materials.

One of the most significant accomplishments was the completion and subsequent 100-percent power demonstration of the Fast Flux Test Facility, meeting its technical specifications. The FFTF was baselined in 1975 with a projected total estimated cost of $647 million and a schedule for 100 percent power demonstration in February 1980. It actually was completed at slightly under $640 million, even though there was a 10-month schedule delay from the 1975 baseline in demonstrating 100 percent power (partly because of a 6-month pipefitter strike, and partly because of other problems). Other FFTF accomplishments can be found in Table 20-1.

Other key LMFBR test facilities that were operational during the fiscal year 1978 to fiscal year 1981 period include the Experimental Breeder Reactor-II, the Hot Fuel Examination Facility, the Transient Reactor Test Facility, the Fuel Storage Facility, the Sodium Components Test Installation, the Thermal Transient Facility, the Sodium Pump Test Facility, the Large Leak Test Rig, and the Small Components Test Loop.

The emphasis of the Liquid Metal Fast Breeder Reactor Program now is on demonstrating the technical and commercial feasibility of LMFBR's by proceeding in cooperation with the electric utilities with the construction and operation of LMFBR plants. Table 20-2 lists current LMFBR Program objectives and prospective milestones in detail.

The Liquid Metal Fast Breeder Reactor Program is one of several long-term DOE programs that could provide essentially inexhaustible supplies of energy for the national economy beginning in the next century. Each such option, if successfully developed, could provide inexhaustible energy for the long term and hence could provide large benefits from the economy and national security; but wisdom dictates that more than one alternative is needed for long-lead technology planning because unforeseeable developments are always likely. These programs require Federal support because even though the potential benefits are large, the return on investment is much longer than the time periods associated with normal industry investments. Based on domestic as well as foreign experience, the LMFBR Program has a high probability of achieving the technical success necessary to ensure economic and market success. Success of the program should ensure the long-term viability of nuclear energy, which in turn provides economic competition in the generation of electric power and a technical alternative to the unlimited use of coal for power generation through the next century.

As a national effort, the LMFBR Program encompasses a wide range of activities by U.S. industry and national laboratories--including research and development work, equipment manufacturing, and the design, construction, and operation of LMFBR plants and test facilities. All U.S. reactor manufacturers have major roles in the LMFBR Program, and a number of leading U.S. architecture-engineering firms also participate. During its earlier stages, the LMFBR Program was assessed carefully in a landmark environmental impact statement; and it meets or exceeds all the strict health, safety, and environmental regulations that have been established for the nuclear industry. From a positive environmental standpoint, deployment of the LMFBR offers long-term benefits by reducing the mining and burning of coal and the mining of uranium.

Fuel Cycle Development. Although the previous Administration deferred the original objectives of the Consolidated Fuel Reprocessing Program (CFRP) by imposing an indefinite moratorium on all reprocessing activities dealing with commercial reactors, the program was given new direction in the interest of advancing non-proliferation objectives and addressing technical barriers to commercial reprocessing. As a result, the development of engineering components and design of facilities proceeded at a reduced level.

During this period, all assigned technical analyses were completed on schedule and within costs, forming a significant technical base for developing non-proliferation criteria and guidelines for proliferation-resistant designs. This included work on advanced fuel reprocessing technology (including the head end, solvent extraction, and product conversion), the thorium fuel cycle, pyrochemical and dry processing methods, evaluation of alternative fuel cycles, and contributions to the Nonproliferation Alternative Systems Assessment Program and the International Nuclear Fuel Cycle Evaluation. The conclusion was that non-proliferation goals could be achieved reliably, safely, and economically through sound engineering practice based in part on the REMOTEX concept and institutional safeguards, without resorting to any alternate fuel cycle.

The Consolidated Fuel Reprocessing Program continued to design, build, test, and modify engineering components and control systems essential to realizing the REMOTEX concept; and, by the end of fiscal year 1981, work was begun in the integrated equipment test (IET) facility to cold test head-end processes in a nonradioactive environment. A part of the IET is the remote operation and maintenance demonstration, in which modular concepts and remote maintenance devices will be developed.

Water-Cooled Breeder. This program is a continuing research and development program. Operation of the proof-of-principle core in the Shippingport Atomic Power Station is an extension of the kind of developmental work that has been carried out at this facility since its initial operation in 1957, using a pressurized water system. Confirmation of breeding at the end of life for the current Shippingport core will mean that the basic reactor technology exists to make about 50 percent of the energy in the Nation's thorium reserves available for power production. This is the only known approach for increasing the efficiency of fuel in light water thermal reactors significantly beyond the 1 percent or so of fuel cycle feedstock achievable at present. Table 20-2 provides current program objectives and a general overview of fiscal year 1982 funding.

Projected Program Requirements

The enacted fiscal year 1982 budget for the Breeder Reactor Systems Program is $678.1 million. Completion of the Clinch River Breeder Reactor Plant (and an accompanying reduction in the scope of research and development activities) will allow subsequent reductions in program costs.

Liquid Metal Fast Breeder Reactor. During fiscal year 1982, more than 90 percent of the CRBRP design will be completed, procurement and fabrication of major equipment will continue, remaining safety issues should be resolved with the Nuclear Regulatory Commission, and activities required for construction should be initiated. In addition to implementation planning with the utilities that will be responsible for construction of the large developmental plant and the advanced conceptual design of key plant systems, safety and environmental documentation for the large development plant will be prepared in fiscal year 1982, and plant-specific research and development requirements will be integrated into the base technology program. All these activities will be closely coordinated with a recently formed utility planning group (Consolidated Management Office) which is funded by the Electric Power Research Institute. Based on preliminary management and financing plans, discussions will be undertaken in fiscal year 1982 with U.S. industry and with other nations on obtaining cooperation on the large developmental plant's design, construction, and operation so that program costs and risks can be minimized.

It is planned that a Breeder Fuel Fabrication Facility will be in operation by 1986 and that the Clinch River Breeder Reactor Plant will achieve criticality within this decade. Planning for providing support for the Clinch River Breeder Reactor Plant will be conducted. A Breeder Reprocessing Demonstration Facility should be operational in time to close the Clinch River breeder reactor fuel cycle.

A 10-percent increase in the level of funding support for the LMFBR Program would allow stepping up procurement for Clinch River (which would result in net savings in program cost), initiating certain research and development activities that have been deferred, and expediting the activities connected with the large developmental plant.

A 10-percent reduction in funding would delay CRBRP activities (increasing program cost in the long run), substantially delay implementation activities for the large developmental plant, and necessitate the deferral of some research and development program work.

Fuel Cycle Development. In the Consolidated Fuel Reprocessing Program, design of the hot engineering-scale facility to provide head-end operations for fast breeder reactor fuels will be based in part on test results from the IET. At the budget level for fiscal year 1982, development of the REMOTEX technology will continue in the remote operations and maintenance demonstration section. Because the REMOTEX concept has no precise precedents, there is a large uncertainty in the associated development costs.

An increase of 10 percent in the fiscal year 1982 budget levels would accelerate equipment development and testing and would permit the start of some programs (such as operator training) which otherwise would be delayed.

A 10-percent decrease would necessarily retard technical progress, delay conceptual design work, and result in the transfer or loss of a vital cadre of specialized engineers and scientists.

Gas-Cooled Fast Reactor. As discussed under Program Objectives above, the Gas-Cooled Fast Reactor Program was terminated in fiscal year 1981. Program costs for fiscal years 1978 through 1980 were about $58 million.

Water-Cooled Breeder. The level of funding for fiscal year 1982 allows for the orderly termination of this program, including defueling of the Shippingport light water breeder core, end-of-life preparations, and the documentation of light water breeder technology. Higher funding would not ensure that the objectives of the program would be met more rapidly. On the other hand, any reduction in the level of support would curtail the development of technical information. This would postpone the availability of LWBR technology to industry.

Transitional Requirements

Liquid Metal Fast Breeder Reactor. Specific termination costs for the LMFBR Program have been estimated only for the Clinch River Breeder Reactor Plant project. Depending on how the termination was carried out, it is estimated that the cost might be between $250 million and $420 million. The variance is a result of the degree to which additional work would be done on the project. If no additional design work were done and the termination activity were limited to the preparation of a final engineering report, the cost would be about $250 million. This amount also includes contractual obligations and reimbursement of utility and industry contributions if required.

Specific termination costs have not been estimated for the rest of the Liquid Metal Fast Breeder Reactor Program; but it is clear that contractual obligations would have to be met and the operating LMFBR plants and test facilities would be decommissioned. The decommissioning of the Experimental Breeder Reactor-II and the Fast Flux Test Facility, as well as the other LMFBR facilities, would undoubtedly be expensive. Termination of the LMFBR Program would probably require hundreds of millions of dollars in addition to the funds required to terminate the Clinch River Breeder Reactor Plant Project.

Fuel Cycle Development. If the CFRP Program were discontinued at the end of fiscal year 1982, closeout costs would involve personnel termination, routine program termination costs such as final documentation, completion of the Integrated Equipment Test facility, satisfaction of landlord obligations, and standby decommissioning costs.

Water-Cooled Breeder. The major portion of the Water-Cooled Breeder Program is now being carried out at the Bettis and Knolls Atomic Power Laboratories. Terminating operation of the light water breeder core at the Shippingport Atomic Power Station will require a 1-year notice in order to train a defueling crew. The end-of-life program will examine the spent core and confirm whether breeding occurred.

(21) ADVANCED NUCLEAR SYSTEMS (NE)

The Advanced Nuclear Systems unit has embraced two different types of activities:

- o Space and Terrestrial Applications--A program to support space exploration and national security activities through the application of nuclear materials in unique fashions to space and terrestrial missions

- o Systems Evaluations--A program to evaluate the development and potential deployment of conventional, specialized, and advanced nuclear systems for various additional applications

Program Objectives

Space and Terrestrial Applications. The overall goal of this program has been to respond to other Federal agencies' requirements for space nuclear power systems and to adapt those technologies, where appropriate, to terrestrial use. The basic objectives of this highly successful program have remained constant for more than two decades, although specific objectives have changed as new missions were identified and as mission milestones were occasionally rescheduled because of spacecraft launch delays. Table 21-1 provides details on program objectives and milestone accomplishments during fiscal years 1978 to 1981.

This program has evolved from efforts to develop nuclear power for aerospace applications that began in the early 1950's. The Department and its predecessor agencies have provided nuclear expertise primarily for missions of the National Aeronautics and Space Administration (NASA) and the Department of Defense.

At present, the program consists of two major projects: developing static outerplanetary radioisotope thermoelectric generators (RTG's) for NASA's Galileo mission in 1985 and the International Solar Polar Mission in 1985-86; and developing the space power advanced reactor for both civilian and military missions in the more distant future.

A radioisotope thermoelectric generator uses the heat from the radioactive decay of material of moderately long half-life, such as plutonium-238, to produce direct-current electrical power by means of thermoelectric converters. Modular designs make it simple to adjust power capacity to specific mission requirements. The General Purpose Heat Source, an improved RTG now under development by the Department of Energy for initial use on the Solar Polar Mission, represents a significant advance in the state of the art of thermoelectric conversion. The General Purpose Heat Source power level (between 255 and 290 watts per converter) is nearly 100 times greater than that of the first RTG used in a satellite mission in 1961. This level will be sufficient to accommodate a great variety of power needs aboard highly advanced spacecraft on long-endurance missions, even in cases where solar energy cannot be used. Because RTG's operate without any moving parts, they have virtually no functional problems; and, in 20 years of satellite and terrestrial assignments, they have met or exceeded all design goals with more than 99 percent reliability.

By applying portions of the technology developed for spaceborne devices, the program also has fostered beneficial uses of certain reactor by-products in terrestrial applications.

There are no similar or duplicative programs in the United States. This program fulfills a unique Federal function in meeting the specific needs of NASA and the Department of Defense for space and terrestrial power systems for research-oriented and national security missions. Civilian applications of terrestrial isotope systems might alternatively be developed by the private sector or by state or local agencies.

Systems Evaluations. This program was a much broader type of effort, oriented more toward analysis than development. It evaluated the feasibility and potential national benefits of new and advanced nuclear technologies and applications including, for example, nuclear energy centers, cogeneration (both for district heating and industrial process heat), and smaller size reactors. The emphasis of these evaluations was on nonelectrical applications of nuclear power and on technologies for improving the acceptability of nuclear plants in areas where such siting considerations as water use and land use may currently prevent their installation. A frequent approach was to conduct case studies of attractive possible technologies and applications under real site or location conditions.

While the potential national benefits of new applications for nuclear energy are great, it is unlikely that surveys of this type would be undertaken by the private sector because of the amount of investment required or the gravity of institutional and other problems. Thus, to the extent that their findings stimulate fruitful interest, such systems evaluations might be considered a unique governmental contribution.

As a special activity under the Systems Evaluation Program, the Nonproliferation Alternative Systems Assessment Program (NASAP) was an ad hoc program formally initiated in early 1977 in response to President Carter's April 17, 1977, Nuclear Policy Statement. NASAP was a comprehensive technical and institutional assessment of the relationship between civilian nuclear power and the threat of nuclear weapons proliferation among nations that did not yet possess such armaments. NASAP's ultimate goals were to provide recommendations for the development and deployment of more proliferation-resistant civilian nuclear power systems, and to support U.S. participation in the International Nuclear Fuel Cycle Evaluation (INFCE). INFCE was organized in October 1977 on President Carter's recommendation to further international cooperation in developing and encouraging such proliferation-resistance measures. INFCE was a major international program in which 44 nations and international organizations participated.

Program Results

Space and Terrestrial Applications. The recent flights past Jupiter and Saturn by NASA's Voyager and Pioneer spacecrafts marked additional milestones in the continuing, successful, and safe use of nuclear electric power in outer space. The striking photographs transmitted from the Voyager I and II spacecraft in 1979, revealing details of the topography of Jupiter and its moons, and the spectacular photographs transmitted from Voyager I in November 1980, and from Voyager II in August 1981, revealing additional rings and satellites around Saturn, were possible only through the use of such nuclear power systems.

Since 1961, the United States has launched 22 NASA and military spacecraft which derived all or part of their onboard power from nuclear systems. Within the past 6 years, significant progress has been made in increasing the thermal output from the radioisotope heat sources (based on radioactive decay) and improving the efficiency of the static thermoelectric converters, which convert the thermal energy into electricity. All technical performance specifications for space missions were met, and all launch date milestones were met.

Future missions committed to nuclear power include NASA's Galileo mission, which will launch an orbiter and atmospheric probe to Jupiter, and the International Solar Polar Mission, which will obtain scientific data on the Sun and solar wind from high altitudes.

The space power systems safety element of the program ensures that only safe and environmentally acceptable nuclear power sources will be flight approved. Related environmental testing and safety analyses will be conducted in support of the safety reviews of the Galileo mission and the International Solar Polar Mission.

The development of safe, high-density fuel forms and specialized encapsulation and handling techniques for this program has long been recognized as potentially useful in civilian applications of some radioisotopes--to draw on their radiant energy as well as the heat they generate spontaneously. Over the years, numerous possibilities have been examined.

Under the terrestrial applications element of the program, a pilot irradiator was constructed and operated successfully at the Sandia National Laboratories as engineering proof that cesium-137 (available in large quantities from defense waste) could be used to irradiate sewage sludge and make it suitable for recycling as fertilizer. Originally, the City of Albuquerque was selected as the site of a larger scale follow-on demonstration; and the Department of Energy agreed to provide engineering and support services for the design and construction of a facility (to be operational in 1987) that would have the capacity to process 33 tons of sewage sludge per day. However, because of budgetary considerations, the follow-on demonstration project is being cancelled.

Systems Evaluations. As of the end of fiscal year 1981, this program has been terminated. This had been a continuing program whose focus was bound to change as perceptions of the most important areas for study evolved. The results of its analyses to date have achieved wide distribution, and have been directed as much as possible to recipients who logically might be most interested in using them. Its general program objectives, schedules, and cost allotments were met, as shown in Table 21-1.

In some cases, specific benefits of the Systems Evaluation Program were easily identified. For example, studies of district heating for the Twin Cities in Minnesota conducted over the past several years (partially sponsored by the Department of Energy) provided vital support to the City of St. Paul in establishing a major downtown district heating project (a system of about 200 megawatts-thermal), which is scheduled for construction shortly. The Water Use Information System developed under this program at the Hanford Engineering Development Laboratory now serves the U.S. Geological Survey, the Department's environmental staff, state water planners, utilities, and other parties in assessing future water supply and usage relative to electric generating plants and other users in all parts of the United States. In addition, the Department-supported concept of using advanced cooling methods to reduce water consumption (and thus expand powerplant siting opportunities) was moved into the test stage by the Electric Power Research Institute's funding of a large developmental unit at a California utility. This type of joint support was a continuing goal of the Systems Evaluation Program.

The Nonproliferation Alternative Systems Assessment Program met its specific technical objectives of supporting U.S. participation in the International Nuclear Fuel Cycle Evaluation and in completing a comprehensive evaluation of the relationships between civilian nuclear power and nuclear weapons proliferation. The final 10-volume report provided a detailed analysis of proliferation resistance, resource utilization, technical feasibility, economics, commercial potential, health and safety aspects, and international acceptability of a wide variety of reactors and fuel cycle systems. The analysis and conclusions were supported by 240 major technical reports by contractors and national laboratories. INFCE itself has increased international awareness of the need to control sensitive nuclear technologies and an understanding of which approaches are most likely to be effective.

Some of NASAP's near-term recommendations were implemented promptly via the Department's light water reactor fuel utilization improvement activities and the Reduced-Enrichment Research and Test Reactors Program (both discussed in PAU #18, "Conventional Reactor Systems") and the REMOTEX fuel reprocessing concept, which is the focus of the Consolidated Fuel Reprocessing Program (described in PAU #20, "Breeder Reactor Systems").

The draft final report of the assessment program was issued in December 1979 for public comment, after a delay of about 5 months which was primarily a result of the extensive technical reviews conducted during its preparation. The program was terminated after issuance of its final report in June 1980. Total direct costs were approximately $28 million.

Projected Program Requirements

During fiscal year 1982, the Space and Terrestrial Applications Program will focus primarily on producing and testing hardware for NASA Galileo spacecraft (scheduled for launch in 1985) and the NASA International Solar Polar Mission spacecraft (scheduled for 1985-86).

The enacted level of funding for Space and Terrestrial Applications is $37.6 million in fiscal year 1982. Further program details are given in Table 21-2.

A 10-percent reduction in funding level would create a serious risk of not meeting the Solar Polar and Galileo launch dates. It would seriously delay safety reviews for both NASA missions, thereby affecting flight approval. It would also delay heat source assembly and flight acceptance tests of RTG's for the Solar Polar spacecraft.

A 10-percent enhanced level of funding would lead to demonstration of improved RTG's by fiscal year 1986 and demonstrate improved safety for NASA and Department of Defense missions planned in 1987 and beyond.

During fiscal year 1982, New Mexico State University will support the transfer of technology that the Department of Energy has already developed, through related research in the economic benefits of sludge irradiation. Fertilizer and soil conditioners for park and farm plots will be evaluated further; biological research will be carried forward; and longer term experiments will be conducted to evaluate the effects of feeding some forms of irradiated sludge solids to cattle.

Transitional Requirements

Closeout costs for this program have not been determined in detail. If funding were discontinued, all fuel fabrication and test facilities would have to be decommissioned and the following objectives could not be met:

- Firm requirements for the electrical power source for the NASA Galileo spacecraft, planned to be launched from a space shuttle in 1985.

- Firm requirements for the electrical power source for the NASA/European Space Agency International Solar Polar Mission spacecraft, planned to be launched from a space shuttle in 1985-86.

- Potential requirements for the space power advanced reactor as the electrical power source in support of Saturn, Uranus, and Neptune orbiter missions planned by NASA for the mid-1990's. The Department of Defense is also assessing use of the solar power advanced reactor for its integrated tactical surveillance system. Completion of component development in fiscal year 1986 would provide the basis for a decision on whether or not to initiate a ground demonstration phase.

- Evaluation of krypton-85 self-luminous lights to meet potential terrestrial military applications, such as lighting airfield runways without the need to rely on external electrical power sources.

(22) COMMERCIAL WASTE MANAGEMENT (NE)

The initial responsibility for managing radioactive waste was given to the Atomic Energy Commission in sections 31 and 32 of the Atomic Energy Act of 1946 (P.L. 79-585). Title II, section 203(a)(8) of the Department of Energy Organization Act of 1977 (P.L. 95-91) set out nuclear waste responsibilities for the Department of Energy. Consistent with this authority, the Department's commercial nuclear waste program is continuing to develop methods to isolate high-level wastes and to identify appropriate sites for the ultimate disposal of certain categories of radioactive material. The Commercial Waste Management Program is also conducting the research and development to manage such wastes safely on an interim basis, leading to their permanent disposal in a safe and publicly acceptable way.

The Department also is giving technical assistance in the development of plans for the safe and efficient management of low-level radioactive wastes, which originate from civilian medical and industrial applications as well as from the operation of nuclear powerplants. Responsibility for the safe disposal of these low-level wastes remains essentially with the individual states.

High-level nuclear wastes produced by national defense activities have substantially different chemical and physical properties from those in the civilian fuel cycle and are handled separately (see PAU #56, "Defense Waste Management"). Nevertheless, much of the technology is interchangeable between the two Federal programs; and progress in one generally produces benefits to the other.

Program Objectives

Broad program goals for commercial nuclear waste management have remained relatively constant since the Department was established, but detailed program objectives have varied in response to Administration and congressional redirection and to changing national needs.

During fiscal year 1981, the Department accelerated its pace toward selection of sites for a Federal repository system for high-level and especially long-lived transuranic wastes, as well as projects to expand the safe storage capacity for spent reactor fuel at commercial plant sites. The latter step should eliminate the need for the Federal Government to store spent fuel in new "away-from-reactor" (AFR) facilities between now and the time reprocessing services for commercial fuel again become available or the repositories are ready to accept material for ultimate disposal.

The Administration is assuming that legislation will be passed that will require financing of the site-specific repository activities through a mandatory fee on utilities. This will allow an expansion of the program and ensure that accelerated milestones will be met.

The specific objectives of the waste repository program are:

- To characterize three different sites (two of which are on DOE-owned land) so that exploratory shafts can begin at all three sites in fiscal year 1983 and be completed in 1985

- To design, plan for, and (starting in fiscal year 1985) construct an unlicensed Test and Evaluation Facility at one of those sites, completing it by 1989

- To choose among the sites that have been characterized, in time to submit a license application for the first full-scale repository to the Nuclear Regulatory Commission (NRC) in 1988

The spent fuel program has been reoriented from its previous goal for federally provided away-from-reactor storage to a new goal of developing technology in cooperation with utilities that can prevent the shutdown of reactors because of lack of storage space for spent fuel.

In accordance with the Low-Level Radioactive Waste Policy Act of 1980 (P.L. 96-573), the goal of the low-level waste program has also been modified. Instead of developing technology to be transferred to industry, the Department of Energy is now providing technical assistance directly to states so that commercial low-level waste management systems can be established at five to seven regional disposal sites.

Another legislative mandate, the West Valley Demonstration Project Act (P.L. 96-368), has given DOE the responsibility for demonstrating the solidification and preparation for disposal of high-level waste (HLW) from the earlier fuel reprocessing activities at West Valley. Canisters of this solidified waste may be made available for possible emplacement (in a retrievable fashion) at the Test and Evaluation Facility.

Thus, the various elements of the Commercial Waste Management Program are both comprehensive and integrated with one another. The current schedule is considered realistic.

Program Results

Table 22-1 indicates the accomplishments made during fiscal years 1978 to 1981 by the National Waste Terminal Storage (NWTS) Program in identifying suitable sites for geologic disposal of high-level nuclear waste in different media and regions of the United States.

The target of characterizing five candidate sites in detail for the first repository has been narrowed to three, but screening of additional ites in other media continues at a low level to permit implementation of a egional repository approach. The three specific sites chosen for intensive tudy include two Government reservations--the Nevada Test Site (where the terranean medium is a compacted volcanic ash material called tuff) and Hanford Site in the State of Washington (in a basalt medium). The third site (to be selected in fiscal year 1983) will be in a salt formation, either one of the interior Gulf Coast domes or a salt bed in Utah or West Texas.

The Department of Energy is planning to begin sinking exploratory shafts at all three sites in 1983. Screening of granitic formations in the north-central and eastern states (plus other candidate media) will be continued for the longer term requirement of a system of regional repositories.

Recently, the Department's program has been reoriented to include a Test and Evaluation Facility. This will provide experience with disposal operations before a full-scale nuclear waste repository is available. The detailed design of the Test and Evaluation Facility to be located at one of the three sites will begin in 1985, and construction of the underground facilities will begin in 1986. Thus, construction could be completed in 1989 to permit receipt of a few hundred canisters of retrievably stored high-level waste in multiple-barrier packages. These canisters could be provided by the West Valley high-level waste solidification demonstration project and other sources. The reference waste form for disposal has been changed from spent nuclear fuel to commercially reprocessed high-level waste as part of the Administration's nuclear waste management policy. Spent fuel also will continue to be considered as a possible waste form.

During the design and construction phase of the Test and Evaluation Facility, underground site characterization activities will continue at the three sites to determine the suitability of each as a repository location. If the site for the Test and Evaluation Facility is selected for the licensed repository, NRC could review a repository license application for that site during the construction and operation of the Test and Evaluation Facility. This also holds true if one of the other two sites is selected for the licensed repository.

The focus of the commercial waste treatment technology program has changed from one of generic technology development to support of specific projects. The high-level waste immobilization activity developed several alternative waste form processes on a laboratory scale and prepared two canisters of actual radioactive high-level waste immobilized in borosilicate glass in 1980.

Characterization and standardized testing of waste forms by a Materials Characterization Center is providing a uniform technique for evaluating various waste forms and testing techniques. Technology and processes developed in the Department's Defense Waste Management Program are expected to be useful in the solidification demonstration effort at West Valley. The selection of an alternative for solidification of the 600,000 gallons of high-level waste at that site is to be made in 1982. An important step in the process for selecting the disposal alternative was completed in 1981 with issuance of a draft environmental impact statement.

In connection with low-level waste (LLW), the Department has also increased its activities--but in this case to provide assistance to states in establishing commercial waste management systems. Results of Department efforts to improve the technology of reducing waste volume will be disseminated widely.

The Department, in response to the policy of the present Administration, has discontinued efforts to provide Federal AFR spent fuel storage.

Instead, the spent fuel storage program has been redirected to concentrate on the development of technology to increase at-reactor storage capabilities provided by utilities. An overall pattern of clear and decisive nuclear regulatory policies and programs should encourage utilities, and industry can provide the necessary facilities and services to manage their spent fuel.

Milestone accomplishments of the overall Commercial Waste Management Program in fiscal years 1978 through 1981 and the budgetary costs incurred in its operation are summarized in Table 22-1. Table 22-2 shows the current program objectives along with fiscal year 1982 funding.

The effects of this program are significant to the Nation's health, safety, and environmental well-being. Its fundamental goal is to ensure that existing and future commercial nuclear waste will be isolated from the biosphere and pose no significant threat to public health and safety. The program has made great strides in achieving its near-term goals, and it will continue to work toward long-term solutions for isolating nuclear wastes from the environment in the future.

Projected Program Requirements

In fiscal year 1982, $226.1 million is budgeted for the Commercial Waste Management Program.

Waste Isolation Program. In fiscal years 1982 and 1983, about half the requested funding is needed for required technology development, while the other half is needed to conduct continued site screening leading to detailed site characterization of three sites. Both efforts are required if a repository license application is to be submitted to the NRC by 1988.

Because of the nature of site characterization--involving time-consuming geologic, hydrologic, and geophysical studies, data analysis, and state and public participation in screening decisions--a slightly higher funding level (for example, 10 percent) would improve the quality and quantity of data to support siting decisions and the licensing process, thus lowering the risks of program failure. A slightly lower budget (for example, 10 percent) would stretch out the program schedule, probably for 1 or 2 years. The goals of the 1985 siting decision on the Test and Evaluation Facility and the 1988 repository license application would be in serious jeopardy.

Low-Level Waste Program. Continued budget authority is necessary to provide funding required to meet the LLW program goal of assisting states in providing a LLW management system by 1988. The Low-Level Radioactive Waste Policy Act sets responsibility for commercial LLW disposal with the states. The Department is committed to assisting the states, industry, and the public in meeting their responsibilities under this act. For fiscal year 1982 through fiscal year 1985, the majority of requested funding is needed to develop technology and make it available to the states. Also included is comprehensive planning and other assistance to the states in their efforts to develop regional LLW disposal sites. These activities are required to ensure that there will be a working regional LLW disposal system by January 1, 1986, when by law LLW regions can exclude out-of-region waste.

An increase in funding would accelerate the technology development program and the transfer of technology to the states. A decrease in funding would limit state support and technology transfer.

West Valley Demonstration Project. New budget authority is required by the project objectives mandated by Congress and supported by the current and previous Administration. In fiscal year 1982, about 60 percent of the requested funding is needed to maintain the West Valley site and to initiate restoration activities to meet environmental, health, safety, and operational needs. The balance of funding permits some planning, development, and design work to proceed. In fiscal year 1983 and outyears, most of the funding will be required for design, procurement, operation, and decontamination, and to upgrade facilities or build supplementary ones.

The preliminary estimate of the project's total cost is in the range of $300 million to $500 million.

Slightly lower budget levels (for example, 10 percent) would stretch out the schedule related to critical design, construction, and operational activities. A slightly higher funding level (for example, 10 percent) would have little effect on the solidification schedule, but the additional funds could be used to start decontamination of the facilities sooner.

Interim Spent Fuel Management. New budget authority is necessary to continue activities concentrating on the development of alternative technologies for interim spent fuel storage. The full development and prompt demonstration of these technologies are needed to give commercial domestic reactors safe, timely, and cost-effective means of providing additional storage capacity until commercial fuel reprocessing and permanent disposal sites are prepared to accept delivery of spent fuel. The Department will participate and share costs with utilities and industry in tests and demonstrations of alternative storage technologies to evaluate their safety and feasibility and to provide the base for Nuclear Regulatory Commission licensing requests. Utilities and industry will provide fuel, facilities, and equipment for these tests plus funding for any site-specific licensing actions. The Federal Government will provide generic equipment and information that can be used by all the utilities. In fiscal year 1982, a licensed test of boiling water reactor rod consolidation will take place. In the following year, a licensed cask storage test is planned.

Because of the relatively low budget authority for the program, a variation of even plus or minus 10 percent would materially affect the level of Federal participation with private industry.

Transitional Requirements

If funding for the waste isolation program were discontinued, no significant additional program costs would have to be incurred, except for closeout costs for all ongoing contracted efforts; but substantial long-term costs are envisioned with respect to the impact on the commercial nuclear power industry (and on the Nation's ability to count on nuclear power as a substantial energy source) if there were no prospect of waste disposal capability in this country.

If the LLW program were discontinued, no significant additional program costs would have to be incurred, except for closeout costs for all ongoing contracted efforts.

If the West Valley Demonstration Project were discontinued, no significant program closeout costs would be incurred; but substantial technical, institutional, and political issues could be expected to arise with Congress, the State of New York, the commercial nuclear power industry, and the public.

If the interim spent fuel management program were discontinued, some utilities might have to use less desirable methods of increasing storage capacity. Some may eventually have no recourse but to shut down, because of insufficient interim spent fuel storage capacity. This would affect the overall supply of the Nation's electric generating capacity and would result in additional costs to utility ratepayers.

(23) MAGNETIC FUSION (ER)

Program Objectives

Fusion is a major energy option offering potential access to an inexhaustible energy resource base. To ensure that fusion will be available as one long-term option, the United States has embarked upon a strong, mission-oriented program to take fusion from its present stage to a point where its potential for practical use can be ascertained. The overall goal of the Magnetic Fusion Energy Program is to develop environmentally sound and economically competitive fusion energy systems. This goal is being pursued through research and development that expands fusion's technical and scientific base. Fusion holds the promise of being developed for power generation and for the production of fissile fuels and synthetic chemical fuels.

Nuclear fusion is a process in which the atomic nuclei of light elements such as hydrogen fuse together to form the nucleus of a heavier atom. The mass of the heavy nucleus is less than that of the reacting particles, and the mass difference is converted to energy. The easiest fusion reaction to attain involves two hydrogen isotopes--deuterium and tritium. For the reaction to occur, these particles must be confined at a temperature of approximately 100 million degrees Centigrade for a time and a density such that the product of these two parameters equals or exceeds 10^{14} seconds per cm^3.

Confinement of the gas (plasma) at these temperatures can occur in one of three ways: by gravitational forces (as in the Sun), by inertial forces, and by the use of strong magnetic fields. Confinement by gravitational forces cannot be achieved on Earth. Confinement by inertial and magnetic methods form two separate programs within the Department. The former has defense applications; the latter focuses on energy applications. The Magnetic Fusion Energy Program addresses two major types of magnetic confinement systems: the toroidal, or closed, donut-shaped configuration; and the magnetic mirror, an open magnetic field geometry whose ends require plugging by various techniques.

The Magnetic Fusion Energy Program grew out of research conducted by the Atomic Energy Commission's physical research programs authorized by the Atomic Energy Act of 1954 (P.L. 83-703), as amended. The commission's legislative authorities in basic research were transferred to the Energy Research and Development Administration by the Energy Reorganization Act of 1974 (P.L. 93-438) and then to the Department of Energy by the Department of Energy Organization Act of 1977 (P.L. 95-91). The Magnetic Fusion Energy Engineering Act of 1980 (P.L. 96-386) provided more specific legislative authority intended to accelerate the attainment of the program's ultimate goal.

Scientists at laboratories and universities throughout the world have been working for many years to discover the scientific principles on which to base a practical fusion energy system. During the 1970's, systematic progress occurred on a broad front. The required temperatures for self-sustaining releases of fusion energy were achieved in several experimental devices. This achievement, together with the demonstration of scaling laws, allows one to predict with confidence that net energy-producing systems are possible. It is now generally acknowledged that there will be a variety of scientific paths to practical fusion reactors. Following these paths to find the best among them will require advanced technology and engineering development of efficient and reliable components and systems.

The Magnetic Fusion Energy Program's specific goals encompass three phases: achieving scientific feasibility, demonstrating engineering feasibility, and developing improved reactor concepts. As the first phase nears completion with the upcoming operation of the Tokamak Fusion Test Reactor (TFTR), the next goal becomes to assess fusion's potential based upon the information developed in the second phase. As the fusion program progresses from one phase to another, it will be supported by a continuing effort and generic physics research. The program's objectives, which are discussed further in Table 23-1, are to:

- Conduct experimental activities aimed at demonstrating and refining methods of heating and containing high-temperature plasma in toroidal and magnetic mirror systems

- Pursue new confinement systems that are potentially attractive alternatives to the current toroidal (especially tokamak) and magnetic mirror approaches, and that contribute to a better understanding of the confinement of plasma by magnetic fields

- Carry out research and development aimed at developing the engineering and technological bases necessary for designing, constructing, and operating increasingly larger and more complex fusion experiments and facilities

- Pursue experimental and theoretical studies of fusion plasma phenomena needed to understand and predict thermonuclear plasma behavior in confinement systems

- Provide for the construction of, and project-specific development for, major new facilities needed to support magnetic fusion research

- Continue and expand, as resources permit, an effort to explore fusion engineering development, including engineering technology options and conceptual design of engineering devices

The Magnetic Fusion Energy Program is not duplicated elsewhere in the Federal Government or in the private sector. Nor do there appear to be any alternatives to Government sponsorship that would maintain fusion as a national energy option. Since commercial applications of fusion energy are not expected to be available until the early part of the 21st century, the private sector lacks the incentive to make the required long-term investment.

The only possible alternative to the present level of U.S. Government support for fusion is to seek a significantly greater degree of contribution from other countries. The effect of this would be to relinquish U.S. leadership in fusion research and development. Under this alternative, one or more governments would enter into agreements that would allocate specific segments of the whole fusion program to specific countries. Information would be shared by all, and research and development redundancy would be reduced to a minimum. Although feasible in principle, this option would entail formidable organizational, administrative, and political problems.

Program Results

There is increased confidence in the United States and in other countries that the goals of the Magnetic Fusion Energy Program can be achieved. This stems in part from progress made in obtaining better values for key fusion parameters (for example, time, temperature, and density) and in part from an enhanced understanding of the basic plasma physics involved. At the same time, experimental results led to optimism that plasma confinement and temperature required for a tokamak reactor could be achieved. The ability to fuel a reactor-grade plasma was demonstrated and the mirror concept was advanced by showing that the tandem mirror reduces end loss, thus reinforcing the belief that the development of power reactors will be based on several approaches to magnetic confinement.

Technological development for fusion continues with the fabrication and installation of equipment on the Large Coil Test Facility and the Tritium System Test Assembly, the collection of data on initial radiation effects on the Rotating Target Neutron Source, and the testing of neutral beam injectors for the Tokamak Fusion Test Reactor. Construction of the next generation of major fusion devices continues, including TFTR and the Mirror Fusion Test Facility.

Because it is a long-term research and development program, magnetic fusion energy's ultimate impact on the national economy cannot yet be predicted in a quantitative sense. However, if fusion is proven to be economically feasible, the Nation would benefit by having a new, essentially inexhaustible energy source.

Increasing attention is being given to the environmental effects of energy systems. Much of the motivation for developing fusion energy comes from the need to minimize the adverse environmental effects of present and future energy sources. Fusion energy holds significant promise of having attractive environmental characteristics. An environmental development plan for the Magnetic Fusion Energy Program was published by the Department in 1978, and a revised version was published in September 1979. The plan is an assessment of the key environmental, health, and safety issues associated ith fusion energy, and includes a description of a program plan for esolving those issues. Based on present understanding, the problems pre-ted by commercial applications of fusion energy can be minimized to eptably low levels of risk.

The current impact of the program stems from the diversity of its performers and its size. The program is distributed among 12 laboratories located throughout the country, as well as approximately 50 universities and 15 major private sector organizations. Government-sponsored industry participation in projects and other magnetic fusion energy activities accounted for approximately $150 million in fiscal year 1980. University programs in plasma physics and other magnetic fusion energy-related subjects help to ensure that the supply of scientists is adequate to maintain the health of the program in the future.

Projected Program Requirements

If program objectives are to be realized, the Magnetic Fusion Energy Program's scientific base must be maintained and its technology base expanded. This long-term strategy will require substantial budget increases, especially in the engineering effort. However, because the need to constrain Government expenditures has been identified as a critical national objective, present and projected funding levels for the fusion program cannot now follow an ambitious path. By necessity the program must be slowed down, resulting in delays, stretchouts, or postponements for several projects.

The fiscal year 1982 appropriation of $453.8 million essentially will provide for continuation of a primarily scientific-oriented fusion program with a limited engineering effort. The engineering effort will continue the ongoing program to develop neutral beams and radio frequency heating systems, blanket and shield engineering, tritium handling techniques, and reactor materials. The plasma confinement effort will be aimed at pursuing the mainline tokamak and mirror concepts through operation of current generation devices. The Tandem Mirror Experiment upgrade will be operating, and fabrication of the TARA device will continue. Construction will continue on the Tokamak Fusion Test Reactor project at the Princeton Plasma Physics Laboratory, the Large Coil Test Facility at Oak Ridge National Laboratory, and the Mirror Fusion Test Facility at Lawrence Livermore National Laboratory.

The fiscal year 1982 budget represents the minimum funding level required to carry out a meaningful scientific program without terminating options prematurely. The budget will allow research to be pursued in a logical and efficient manner to generate a sufficient data base that will permit the development of fusion technology to move forward with minimum risk in the future. Activities in fiscal year 1982 are directed at this goal either through improved performance, reduced costs, more effective options, or better understanding for subsequent research decisions. Reductions below the fiscal year 1982 appropriated level would introduce an unnecessarily large amount of risk in achieving the program's goal. An increase in the funding level would allow for an increased effort in technology activities related to the preparation of a fusion engineering device and restoration of projects that have been terminated. Continued increases in funding support could help reduce the time required to determine fusion's potential for eventual applications and thereby reduce the total development cost.

Transitional Requirements

The Magnetic Fusion Energy Program employs approximately 2,500 professional scientists and engineers nationwide and an estimated equal number of nontechnical support personnel. If funding were discontinued, penalties for terminating existing contracts would be payable to contractors. In addition, agreements between the United States and several other countries have been signed, or are being negotiated, for cooperation in fusion research and development. Since these agreements are entered into at the government-to-government level, the international implications of termination of the program must be considered.

If the Magnetic Fusion Energy Program were placed under another Federal agency, careful planning would be necessary to ensure that personnel and facility transfers were accomplished with minimal program disruptions.

c. Renewable Energy

OVERVIEW The term "renewable energy" in popular usage seems to connote what is called "soft technology" (with solar energy as its lead component). By tradition, however, the annual report of the Department of Energy has been more literal and has acknowledged that any energy technology that can draw on a virtually unlimited resource base can be placed under the heading "renewable." Thus it has included the breeder reactor, geothermal energy, and nuclear fusion, as well as large-scale or small-scale hydropower, wind energy, and biomass fuels. The categorization in this report is slightly different still; but it is probably most faithful to the programmatic management pattern that has existed within the Department of Energy since it was established. The seven program analysis units (PAU's) in this section deal with the nonnuclear and nonmineral energy sources of greatest interest--the Sun, wind, water, Earth heat, and biomass (including both direct combustion fuels--such as wood--and those such as alcohols that are based on biomass). The actual PAU grouping follows the Department's organizational lines for ease in compiling and comparing budget allocations.

Progress toward the national objectives for each of these individual energy forms has been quite satisfactory. Technologies have advanced, suppliers have multiplied and improved, public acceptance generally has been good, and the users' market has expanded--with sales of all renewable technologies growing about threefold within 4 years.

Despite technological success and impressive percentage growth, however, renewable energy forms (except for hydropower and the wood wastes that long have been used in the pulp and paper industry) remain a small factor in the overall national picture. Active solar, geothermal, and wind systems together produced no more than 0.03 quad during fiscal year 1981--a few one-hundredths of 1 percent of national energy consumption. It can be argued persuasively that their potential for the midterm to distant future is great; but the critical factors governing their projected rate of growth are primarily economic: their cost per Btu, including amortized capital investment; the comparable costs of competitive energy sources, including all forms of conservation; and the overall health of the U.S. economy. This recognition underlies a change in focus and objectives for most of the renewable energy programs, which coincides with the change in Administrations.

Many of the original objectives of the various subprograms have been met. Privately funded and Federal research has led to a fuller understanding of virtually all major renewable technologies. A broad spectrum of economic incentives which could be used for renewable energy investments are now in place, augmented considerably by the enactment of the President's Economic Recovery Tax Act of 1981 (P.L. 97-34). Several states, because of their location within highly advantageous resource areas or because of local economic factors, have enacted additional incentives which favor the growth of renewable energy industries. The stage is set for another phase of development, in which the Federal Government's most helpful role is different from that of the past few years. Instead of attempting to force the increased production of renewable energy systems at any cost, the aim now is to allow the marketplace to determine the pace of future growth.

Prior to the 1970's, research activities on new and renewable technologies were narrow in scope. In terms of funding and direction, they were keyed largely to the needs of the national space program. By the early 1970's, the Federal Government was still dedicating only a few hundred thousand dollars annually in funds for research in this area; but by the middle of the decade, public and governmental interest had exploded suddenly. The first spurt in oil prices and the simultaneous impending threat of energy shortages sparked a desire to explore all feasible replacement sources--and especially those that were widely regarded as environmentally benign. From then on, major legislative initiatives laid the groundwork for the programs treated in this section. Among the guiding statutes were the following:

- o The Energy Reorganization Act of 1974 (P.L. 93-438), which consolidated functions relating to solar and other renewable energy research into the Energy Research and Development Administration (ERDA)

- o The Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409), which established a program to demonstrate experimental prototypes of solar heating and cooling technologies for residential and commercial buildings applications and to determine their economic and technical feasibility

- o The Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473), which charged ERDA with coordinating research, development, and demonstration activities of several Federal agencies (including the Atomic Energy Commission, the National Aeronautics and Space Administration, the Housing and Urban Development Agency, the National Science Foundation, and the Federal Power Commission)

- o The Geothermal Research, Development, and Demonstration Act of 1974 (P.L. 93-410), which established the National Geothermal Energy Coordination and Management Project (now the Interagency Geothermal

Coordinating Council) and authorized a Geothermal Loan Guarantee Program

- The Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), which established a comprehensive national program of research and development for potential alternatives to conventional energy sources, including solar, geothermal, and other renewables

- The Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 (P.L. 95-590), which established an aggressive research, development, and demonstration program for photovoltaic systems to produce electricity that is cost-competitive with utility-generated electricity

- The Energy Security Act of 1980 (P.L. 96-294), which authorized financial assistance to a number of renewable technologies in order to encourage their commercialization

- The Ocean Thermal Energy Conversion Research, Development, and Demonstration Act of 1980 (P.L. 96-310), which established specific national development goals for what was considered the most promising of the ocean energy systems, OTEC

- The Wind Energy Systems Act of 1980 (P.L. 96-345), which established specific program objectives for the wind energy program

Additional legislative mandates are noted in some of the individual PAU's.

The basic motivation for establishing the Department of Energy was to assemble Federal energy activities of all types within one organization. Initially, renewable energy programs were placed under the cognizance of DOE's Assistant Secretary for Energy Technology. As the programs were considered ready for commercial demonstration they were shifted either to the Assistant Secretary for Conservation and Solar Applications or to the Assistant Secretary for Resource Applications. Later, all renewable energy functions were consolidated under the Assistant Secretary for Conservation and Renewable Energy. Historically, the renewable energy strategy centered around the following activities:

- Characterizing market needs

- Performing basic, applied, and developmental research and development as necessary to define the costs of renewable technologies in early development stages

- Identifying and selecting cost-competitive applications for renewable technologies and determining appropriate Federal roles in development

- Performing research and development to reduce costs of selected renewable technologies in advanced development stages

- Supporting commercialization

In the beginning, all these elements may have been required--in view of the fact that controlled prices on conventional energy discouraged competition from renewables. Now that the price of oil has been decontrolled and the regulation of wellhead prices for natural gas is being phased out under the Natural Gas Policy Act of 1978, however, incentives for private investment have increased. In addition, the Administration's Economic Recovery Program gives the private sector greater ability to raise capital and increase investments. Furthermore, technology has been improved and feasibility has been demonstrated in a variety of cases.

Active solar energy systems are now being used in between 300,000 and 400,000 U.S. buildings. A solar-supply industry that was virtually nonexistent in 1975 ($17 million in sales, with about 50 manufacturers of solar collectors) has grown to more than 300 firms, projecting sales this year in excess of $300 million. For many of these suppliers, the DOE demonstration program was practically the only source of sales during the period of early development, but this is clearly no longer the case.

As a result of the Federal photovoltaic research and development program support since 1972, the technology base for cells, subsystems, and systems has been advanced to the point where industry is already realizing significant cost reductions and improved reliability. In particular, the efficiency of commercial silicon cells and arrays for terrestrial applications has been increased about 100 percent, the operational and lifetime reliabilities improved by about tenfold and, at the same time, the cost of arrays was reduced by a factor of about five over the past 7 years. The number of photovoltaic array producers has increased from a few U.S. speciality companies using expensive manual production processes for space applications to more than 15 current U.S. producers, many of whom use semiautomated pilot production lines to serve the growing terrestrial market. Industrial sales increased from a few kilowatts (peak) in 1975 to an estimated 5 megawatts (peak) in 1982, which amounts to array sales of about $75 million. These developments have made photovoltaic systems particularly economical for a large number of remote, stand-alone electric power supply applications. Cost of crystal silicon cells should be further reduced in the near future based on research and development results now available to industry for reducing costs of solar-grade silicon materials and silicon sheets. Research and development advances in a number of new thin-film materials are providing the technology base for longer term industrial development of the next generation of photovoltaic technology.

Over the past several years, 13 large wind turbines (that is, those with individual outputs of more than 100 kilowatts) have been installed in this country, with a combined capacity of nearly 15 megawatts; and 3 of the largest wind turbines in the world (the 2.5-megawatt MOD-2's) have been placed at one site in the State of Washington and tied to the Bonneville Power Administration grid. Because the market for either large or small wind machines is site-specific, "National Wind Resources Atlases" have been published for all 50 states and U.S. territories to encourage applications whenever feasible. Although annual sales of small machines are still in the range of a few thousand, the maturity of the industry is indicated by the fact that more than a score of firms are engaged in manufacturing and marketing them. As in the case of all renewable energy sources, the adoption of wind turbines as a large-scale means of generating electricity depends on relative costs in a given area. The establishment of commercial "wind farms" on both coasts is a sign of genuine interest on the part of private enterprise at this time.

Hydropower is, of course, a mature technology. Nevertheless, activity at small sites (so-called "low-head hydro") was dormant by the mid-1970's because of the inability of such installations to compete then with large central station thermal plants. Since 1977, DOE has supported 20 key construction projects and has provided grants to 40 states for hydropower resource assessments, studies to identify and to eliminate institutional barriers, and other necessary planning. Primarily as a result of higher energy prices, coupled with small power producer incentives, the number of regulatory applications for low-head hydro projects sharply increased from 130 during the 4 years prior to 1980 to a 1-year total of 600 in 1980. In 1981, the Federal Energy Regulatory Commission reported that they have received 1,856 applications, more than triple again; and U.S. equipment suppliers have large backlogs of orders. Now that the industry has been revitalized, further direct intervention by the Federal Government is unnecessary.

Geothermal energy represents another success story. Promising geothermal resources have been identified in 37 states, including some areas of low to moderate temperature in the eastern United States that could be of practical value if application techniques now under development prove successful. By 1983, advanced technology should be available to meet the objective of cutting drilling costs by 25 percent; and the reservoirs already confirmed are adequate to allow private industry to meet the goal of the Interagency Geothermal Coordinating Council (chaired by DOE's Assistant Secretary for Conservation and Renewable Energy) of 3,000 megawatts-electric of electric capacity by 1985 if favorable economic trends continue. Finally, the technology for using geothermal heat directly for space heating and process heat is well developed and (in certain areas) economical.

The Office of Alcohol Fuels at DOE has been in existence a relatively short time. However, it is now clear that the goal assigned to it by the Energy Security Act of 1980 to reach 920 million gallons a year of alcohol fuel production and use by 1982 will not be met. It is estimated that alcohol fuel production capacity by the end of 1982 will be no more than 400 million gallons per year with active production and use lagging behind capacity. The current grain-based conversion process is not economical without current subsidies. Recognizing this, industry is pursuing the development of alternative processes and feedstocks as well as improvements in the engine efficiency of alcohol fuels as compared with gasoline. In the long run, the widespread adoption of "gasohol" mixtures must depend on the valid competition of that fuel rather than on excessive tax concessions and financial assistance programs that subsidize its price.

The growth in the number of buildings employing "passive" solar energy systems--those that save energy by using designs that capture the Sun's winter rays, store the heat in masses of concrete or stone, and then dissipate the heat slowly at night, and by using other techniques such as coated windows--is equally impressive. The number of identified passive solar houses has grown from 500 in 1977 to an estimated 60,000 by the end of 1981. This growth has taken place in every climatic region of the country during a period of declining new home construction. Several major building trade associations have established staff and projects relating to passive solar design. Further growth in the use of passive solar can be expected, especially as the economy improves under the President's Economic Recovery Program and as some of the innovative passive systems currently under development become more cost effective.

Ocean energy technology programs have examined the feasibility of the various technical options possible in waves, currents, tides, salinity gradients, and thermal gradients (temperature differentials at various depths). Of these, thermal gradient systems offer the most promise for near-term commercial use. This is supported by the successful demonstration of technical feasibility of a 10-kilowatt experimental unit and a larger scale, 1-megawatt, ocean-based test facility.

Across the board, the goal today of renewable energy programs within the Department of Energy is to support private sector efforts to improve the technical performance and economic competitiveness of the most promising technologies through a program of basic and generic research that provides a technology base for industry.

Although the PAU's make note of some possible adverse environmental consequences, renewable energies as a class are remarkably free of such problems. Although they may generate some pollutants and raise some aesthetic objections, net environmental analysis shows that their continued emergence can reduce substantially the burdens of carbon dioxide, sulfur, and nitrogen compounds we otherwise might have to tolerate if energy consumption increases.

Because many renewable energy sources tend to have intermittent outputs, the development of efficient, effective, and reasonably priced storage systems is often a critical factor in their individual economic prospects. Work on those systems, however, is treated in the following section of this report, which is titled "Conservation and Energy Systems." The Department of Energy's largest direct involvement in hydropower is its association with Federal dam projects through various power marketing administrations. This is treated in the section of this report titled "Energy Production and Power Marketing."

(24) SOLAR APPLICATIONS FOR BUILDINGS (CE)

The Department of Energy activity designated as "Solar Applications for Buildings" has included efforts on three solar technologies related to the building sector: active heating and cooling; passive and hybrid systems; and photovoltaics.* Recently the elements of this program have been realigned into two general areas: solar heat (linking the first two) and solar electric (which includes photovoltaics). The solar thermal subprogram (which formerly was part of the program dealing with solar applications for industry and thus is treated within this report in PAU #25) also was made part of the new Solar Heat Technologies Program.

Work on both active and passive systems for solar heating and cooling can be traced to four key laws enacted by the 93rd Congress: the Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409); the Energy Reorganization Act of 1974 (P.L. 93-438); the Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473); and the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577). Under the Department of Energy Organization Act of 1977 (P.L. 95-91), authorities of the earlier legislation were assigned to the Department of Energy. In addition, the National Energy Conservation Policy Act of 1978 (P.L. 95-619) greatly expanded the role of the Active Solar Heating and Cooling Program in promoting solar projects in the Federal sector and for schools, hospitals, and public buildings. And, finally, the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 (P.L. 95-590) was enacted to establish "an aggressive research, development, and demonstration program" for photovoltaic systems to produce electricity "cost competitive with utility-generated electricity."

Because of differences in the nature of the three technologies covered by this PAU--as well as the varying degrees to which original objectives have been achieved--the respective components will be treated separately.

ACTIVE SOLAR HEATING AND COOLING

Program Objectives

Historically, the goal of this program has been to accelerate improvement of an industry to build and install active solar systems in buildings. The means by which this was to be accomplished were reduction of system costs, improvement of system performance, and enhancement of system reliability

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*In practice, photovoltaic systems are potential suppliers of electric energy to industries and utilities, as well as to buildings.

through research and development efforts, as well as accelerated commercialization of active solar technologies in the residential and commercial buildings sector through demonstrations and market development activities.

In accordance with specific congressional mandates, the Department of Energy established a research and development program, the National Solar Data Network, a Commercial Demonstration Program, and the Solar in Federal Buildings Program. Specific criteria and measures of evaluation were developed for activities and projects funded under these programs, and particular emphasis was placed on incorporating basic conservation and load-reducing strategies, progressive cost sharing, and cost/performance advances in the successive demonstration cycles.

Growth in the active solar industry has been substantial, and market conditions have changed considerably because of the rising cost of the traditional energy forms used for space heating, water heating, and cooling, thereby providing an alternative to a Federal program. Additionally, electric power utilities already are examining solar programs to determine how active systems could affect their traditional delivery systems and costs. State and local government programs exist and involve promotional work and, to a limited extent, developmental activities. At the same time, the Administration has put greater stress on competitive market forces while reducing or eliminating unnecessary Government intervention in the form of preferential support for demonstrations of specific energy types. For these reasons, the current objective of the Active Solar Heating and Cooling Program is to phase down or close out its activities in an orderly fashion during fiscal year 1982. During this fiscal year, work in progress will be completed in materials and components, testing, control methods and devices, high-performance solar-assisted heat pump components, and solar ponds for low-temperature thermal applications.

Program Results

The Active Solar Heating and Cooling Program (first under the Energy Research and Development Administration and then under the Department of Energy) has made considerable headway in accelerating the establishment of an industry. Up until 1974 there was virtually no market for solar heating equipment; but by the end of the funding cycle for the last demonstration program (in fiscal year 1979) more than 700,000 square feet of solar collectors had been purchased in this country. They were for use in about 1,250 residential units involving more than 270 commercial-size projects and involved more than 70 suppliers of solar equipment.

Although the Government program is not solely responsible for the growth of the industry, the Department's demonstration program was the prime source of sales for many of these suppliers during their early development. At the same time, the Department conducted research and development (for example, by improving collector performance and solar cooling equipment) and a market development program (for example, disseminating information and helping to develop consensus codes, standards, testing procedures, and training methods). Table 24-1 summarizes program accomplishments for each of the past 4 fiscal years.

Hundreds of manufacturers, distributors, dealers, installers, and professionals such as architects, designers, and engineers benefited from financial support and "hands-on" experience through project involvement. State and local governments have received guidance from the Department in drafting solar building codes, as well as in testing and certification procedures. The general public has been given information about how to apply solar technology; and it also has been served by the development of market standards, including warranties.

The active solar industry, also aided by Federal and state tax incentives, projected sales in excess of $300 million during 1981--up from only $17 million in 1975 and $172 million in 1977. From fewer than 50 manufacturers of solar collectors in 1975, the industry grew in 6 years to more than 300 firms. The entire industry now employs thousands of skilled tradesmen and professionals. The total fuel savings from the 300,000 to 400,000 systems that have been installed are estimated to be the equivalent of between 1.0 million and 1.5 million barrels of oil (0.006 to 0.009 quad) annually. The overall effect is still minor, but generally it has been to increase employment. The widespread use of the technologies may help to reduce air pollution by displacing nonrenewable fuel sources whose combustion products are potentially harmful.

Projected Program Requirements

In fiscal year 1982, this program has received appropriations of $11.5 million. This will be used to terminate the program in an orderly fashion by the end of fiscal year 1982 and to complete research and development in high-risk, high-payoff areas that industry is unlikely to support. Further progress is expected in materials and components research, testing, control systems, components for high-performance solar-assisted heat pumps, and solar ponds for low-temperature thermal applications.

The Active Solar Heating and Cooling Program is being phased out because of the recent rises in the prices of fuels with which solar energy must compete, and because of an enhanced environment for private sector investment (which should be sufficient to sustain the industry's growth).

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

PASSIVE AND HYBRID SOLAR ENERGY

Passive solar energy techniques involve the use of thermal storage walls, careful placement of windows and living spaces, and other methods that displace requirements for heat and light that otherwise could be satisfied only by consuming conventional fuels. If passive solar designs for buildings also include some active solar devices (solar heat collectors or photovoltaics), they are classified as "hybrid" installations.

Program Objectives

The goal of the program has been to accelerate the development of a passive-hybrid buildings industry. Specific objectives toward meeting this goal (and the degree to which they have been met) are described in Table 24-1.

While this effort is being phased down as a separate program, emphasis during fiscal year 1982 is being placed on technological advances that could improve performance and reduce costs ultimately in integrated systems, which provide a combination of heating, cooling, daylighting, and hot water. Research is seeking increased understanding of fundamental physical phenomena, but also avenues of development for reliable materials, components, and systems. The aim is to support technologies that can be developed within 4 years to the point where feasibility can be demonstrated for integrated heating and cooling systems that would reduce average annual energy use in typical residential buildings by 35 percent on a continuing basis, at a capital cost of $195 per million Btu's of annual capacity. For commercial buildings the target figures are 15 percent and $375 per million Btu's per year, respectively.

The Solar Energy Research Institute (SERI) and several national laboratories serve as focal points for specific subject areas. For example, SERI is the lead center for the design methods and performance data program elements. Los Alamos National Scientific Laboratory leads research in heat transfer for heating systems, and Lawrence Berkeley Laboratory concentrates on cooling technologies. Other Federal agencies, such as the Department of Housing and Urban Development, have included passive solar technologies in their programs. Private sector technology transfer activities are coordinated through the Passive Solar Industries Council, representing 31 national associations in the building industry. International activities have been coordinated through the NATO Committee on the Challenges of Modern Society program and SERI.

Program Results

Between 1978 and 1981, it is estimated that consumption of more than 500,000 barrels of oil equivalent (an average of about 0.001 quad per year) was displaced by passive systems. While this is still a relatively modest overall saving, the market for passive buildings actually has been expanding exponentially during the past 4 years. These are continuing (rather than "one-time") savings, and it is estimated that passive buildings will displace more than 27 million barrels of oil equivalent (0.15 quad) by 1990.

Since 1978, several basic heating systems have been replicated and standardized, and methods have been developed to predict performance, so that new cost and performance indicators can be identified in the future. These basic heating systems are now reliable, and greater control can be exercised over the interior environment. The development of various high-performance materials and components has been pursued in joint programs with industry. Infrared reflecting films, phase-change storage materials, moveable insulation, low-emissivity coatings for glass, dehumidification systems, earth-air heat exchangers, and heat pumps have been developed. In its own way, each should improve the future collection, storage, distribution, regulation, and/or rejection of heat energy in passive solar building systems.

Research has been conducted in the basic natural phenomena and heat-transfer characteristics of radiative, evaporative, ventilation, and dehumidification systems. There also has been research on convection heat transfer and control mechanisms. Products of the Department of Energy's efforts include two design handbooks, at least a dozen manuals, and adaptation or development of four mainframe computer codes and two manual design methods. There have been prototype building and field tests, 24 test cells, 19 instrumented buildings, and direct technical assistance for more than 600 buildings. Other major accomplishments include computer forecasting and market-indexing models, a university architectural curriculum, and more than 250 workshops, which reached more than 13,000 professionals.

In 1977, there were fewer than 500 passive solar residential buildings in the United States. By 1980, there were 25,000 passive solar residential buildings and about 100 passive solar commercial buildings in diverse climatic regions.

However, most passive systems installed thus far supply only small amounts of solar energy at high initial cost. Current delivered energy costs for several innovative passive systems are 2 to 3 times higher than the costs projected to make them economically competitive with conventional fuels. Research and development still must be done to overcome the remaining technical challenges impeding the development of cost-effective integrated passive systems.

Projected Program Requirements

For fiscal year 1982, $10.6 million has been appropriated for this program. These funds will be used to phase down the existing program and to complete research and development on passive solar materials and designs. The market in passive and hybrid systems is now considered sufficiently broad-based to allow the private sector to develop the market for these systems.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

PHOTOVOLTAICS

Photovoltaic systems have been used for onboard power by space vehicles for more than 20 years, and they are being sold currently for a limited number of specialized remote terrestrial applications where no other source of electric power is practical. The underlying objective of the Federal program has been to accelerate the development of photovoltaic technology that would be technically and economically capable some day of supplying a substantial portion of U.S. electric power requirements. Some of the problems the program has addressed include high costs, low efficiencies, and uncertain lifetimes of photovoltaic collectors; the lack of appropriate power conditioning and other balance-of-system components; and the technical, economic, and legal difficulties of integrating photovoltaic systems into electric utility grids.

Photovoltaic systems produce electrical output only in daylight hours, and they primarily would displace high-cost peaking and intermediate generation; conventional baseload energy sources would not be displaced until very high market penetration levels of photovoltaics occurred. Thus, while some Federal programs for advanced applications of conventional fuels and other renewable systems also aim at intermediate and peaking generation, the Federal programs directed at baseload electricity generation are not in direct competition with this one.

Program Objectives

The goal established by the Solar Photovoltaic Energy Research, Development, and Demonstration Act was to establish "an aggressive research, development, and demonstration program" for photovoltaic systems to produce electricity "cost competitive with utility-generated electricity." Specific objectives for a 10-year program included doubling the annual production of photovoltaic systems each year, culminating with 2,000 peak megawatts to be produced in fiscal year 1988; reducing the average cost of installed systems to $1.25 per peak watt by fiscal year 1988; and ensuring that at least 90 percent of photovoltaic systems sold in fiscal year 1988 are purchased by private buyers. The act authorized the expenditure of $1.5 billion over 10 years to achieve these objectives.

The act required the Secretary of Energy to report to Congress on the feasibility of achieving the act's objectives or to offer alternative objectives. Meanwhile, the Domestic Policy Review of Solar Energy suggested that 1 quad per year of primary fuel could be displaced by photovoltaics in the year 2000. The Secretary's report of February 20, 1980, examined seven program options and indicated that the level of funding authorized by the act was unlikely to ensure the achievement of the fiscal year 1988 production objective.

Present Department policy shifts the program emphasis away from production or penetration levels and focuses instead on establishing technical feasibility. It is concentrating on long-term, high-risk, potentially high-payoff research and development, but it will continue to carry out the overall mandate of the Solar Photovoltaic Energy Research, Development, and Demonstration Act to the extent feasible within the limits of appropriated funds. The major goals and objectives to be met are listed in Table 24-2.

Photovoltaic research and development, including field testing, is expanding rapidly in Europe and Japan in response to the near-term market for remote, stand-alone units to supply direct-current (DC) electricity and the longer term prospects of widely distributed alternating-current (AC) systems and even use in central station generation. Japan's efforts in the commercialization of low-cost amorphous silicon cells (for uses ranging from small calculators to standard rooftop arrays) are exemplified by Sanyo's $50 million, four-story plant, the world's largest factory, now nearing completion. By mid-1982, Sanyo expects to be producing a million modules a year of 38 peak watts each.

The principal alternatives to the current research and development program strategy in the United States (emphasizing long-term establishment of technical feasibility) is a policy of leaving further research and development entirely to private firms.

Program Results

A summary of accomplishments and annual operating costs of the program for fiscal years 1978 through 1981 is presented in Table 24-1. Accomplishments in various areas are evident.

- Research and development in the advanced materials, cells, and concepts area has achieved a 10-percent conversion efficiency in the laboratory for several potentially low-cost, thin-film solar cells.

- Research and development on collectors demonstrated the technical feasibility of $3.08-per-peak-watt collectors in 1980, and is well along the path toward showing the technical feasibility of $0.77-per-peak-watt collectors by fiscal years 1984 and 1985. By 1988-89, this element of the program projects the technical feasibility of less than $0.45 per peak watt for the new thin-film materials currently undergoing research and development in the advanced materials area.

- Work in the system and subsystem research and development area already has developed initial photovoltaic system designs for three levels of utility-connected applications. Two residential experiment stations also have been established to test prototype hardware and systems under simulated residential conditions.

- In the system experiments area, a series of first-ever photovoltaic experiments has been initiated to provide feedback to the research and development community on the performance of hardware and systems that are available currently.

- The final area, market development, was built around the Federal Photovoltaics Utilization Program. Congress authorized a 3-year, $98 million program, although only $24 million actually was appropriated during this period. A total of 2,772 unit-applications (ranging from a few watts to 25 peak kilowatts) were installed by 26 participating Federal organizations in four cycles of procurement. The principal accomplishment was to make Federal agencies more aware of potential photovoltaic applications and to develop the ability of contractors to supply photovoltaic systems.

Major private sector participation in research and development and venture capital commitments is evident. Several firms are poised now for entry into the field or for expansion of present commercial commitments.

According to recent surveys, there are already 300 firms, universities, and other organizations active in the photovoltaics field in the United States and about 385 worldwide. The three largest module manufacturers account for about three-fifths of all shipments. The 1980 module shipments are estimated to have been nearly 4 peak megawatts, with revenues of $40 million to $50 million--about twice what they were the previous year. The greatest increase of private investment (estimated at $100 million in 1980) is in proprietary research, manufacturing, and marketing.

The direct beneficiaries of the Department of Energy's Photovoltaics Program are private firms involved in the manufacture, assembly, installation, sale, and service of photovoltaic systems; the electric utilities seeking long-term power options; and the general public, which eventually might gain a new renewable energy option to compete with fossil energy systems.

Other beneficiaries include industries aided by scientific and technological spin-offs from the photovoltaic research and development program. For example, it is estimated that reductions in the cost of producing silicon wafers could ultimately save up to $1 billion for the electronics and computer industries and their customers.

Nevertheless, the major impacts on the national economy from the Federal Photovoltaics Program, past and present, will not be felt until after 1990. Its key economic benefits will be the "avoided" energy costs resulting from the accelerated deployment of various types of photovoltaic systems by electric utilities. These fall into four categories: displacement of conventional fuel; displacement of generating capacity; transmission and distribution credits; and operations and maintenance credits. To achieve these goals in this time period would require extensive additional development, however. Photovoltaic systems will not be capable of serving in utility-connected applications until their costs drop to one-tenth of their present relative level.

Photovoltaic systems appear to offer environmental benefits when compared to the conventional sources of electrical power that they could displace. They can be silent and use passive cooling. They emit no effluents, and their manufacture does not produce harmful emissions or waste products. The dominant photovoltaic material, silicon, is abundant and chemically inert. The production of photovoltaic systems does not depend on the availability of strategically vulnerable materials. Their energy source is secure and inexhaustible. Furthermore, photovoltaic systems have the advantages of using no moving parts and being inherently modular in design--so they can be scaled up or down easily to meet specific capacity requirements.

Considerable attention has been focused on worker health and safety in the manufacturing facilities for photovoltaic collectors. Manufacture of some advanced photovoltaic cells could expose workers and neighbors of plants to toxic substances; but adequate substance control technologies either exist or can be developed to mitigate possible hazards. The Photovoltaics Program has actively promoted the development of control technology to ensure worker safety from toxic exposure.

The land requirements of photovoltaic arrays are substantial, yet they may be no greater in the long run than those of other energy sources they are intended to replace (if the land areas involved in mining or drilling phases are considered). In fact, overall land requirements for photovoltaic systems might well be less because of photovoltaics' modularity, the lack of onsite effluents, and the adaptability to existing structures, such as rooftops.

Projected Program Requirements

The program has received appropriations of $77.0 million for fiscal year 1982 to continue essential research. However, reduced funding for the program will be requested for fiscal year 1983.

Even though the larger participants in the photovoltaic industry have already made sizeable investments, rapid development of photovoltaics still involves substantial technical and economic risks. Furthermore, utility applications still face serious uncertainties about interface requirements, system design and performance, safety, reliability, lifetime, and maintenance; and it is not clear now which technical approaches and products will succeed. Nor is it certain that present cost targets can be met. This greatly increases the normal risks of product failure and the obsolescence of production facilities. Because of these costs, risks, and uncertainties, it is likely that the industry initially will focus its attention on the much simpler stand-alone remote markets.

Future investments by U.S. industry in component and product development for the domestic utility-connected market will be sensitive to the risks, costs, and uncertainties just described. The necessary generic system tests and evaluations are costly, and industry hesitates to fund them because they are likely to benefit competitors as much as they do the pioneering firm. Thus, the Department's Photovoltaics Program is focusing exclusively on the critical component research and development and the initial prototype system tests that can lead to the technical feasibility of cost-effective utility-connected systems.

Information generated by the program should assist private firms in making efficient investment decisions, facilitate the contribution of ideas by smaller firms, encourage technical diversity and competition, and lead to the earliest reasonable commercial availability of cost-effective systems. The remaining risks and cost to industry of establishing the final commercial readiness of photovoltaic systems is expected to be low enough so that firms will invest in their own product development, testing, and marketing. The specific program objectives and budget requirements are summarized in Table 24-2.

Funding variations of plus 10 percent or minus 10 percent might accelerate the schedule for achieving cost and performance objectives by 7 months or delay it by 1 year, respectively. Reduced funding would stretch out the timetable more than a corresponding funding increase would accelerate it because there are significant fixed commitments to monitor and evaluate existing experiments and because a funding cut would mean more contract efforts would have to be carried out sequentially rather than concurrently.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(25) SOLAR APPLICATIONS FOR INDUSTRY (CE)

The Department of Energy activities designated as "Solar Applications for Industry" include efforts on two solar technologies that relate primarily to the industrial sector: biomass energy systems and solar thermal energy systems. Related programs in geothermal, hydropower, municipal solid waste, active and passive solar energy, and alcohol fuels are discussed separately in this report.

While activities in both biomass and solar thermal energy development began before 1974, the major program mandates can be traced to three key laws enacted during the 93rd Congress: the Energy Reorganization Act of 1974 (P.L. 93-438); the Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473); and the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577). The Department of Energy Organization Act of 1977 (P.L. 95-91) transferred responsibility for policy and management of research and development for all aspects of solar energy resources to the Department. In addition, the Department of the Interior and Related Agencies Appropriations Act for Fiscal Year 1980 (P.L. 96-126) initiated the Department of Energy's alternative fuels program, and the Energy Security Act of 1980 (P.L. 96-294) provided for a program "for increased production and use of biomass energy" to "reduce dependence of the United States on imported petroleum and natural gas." Finally, the Solar Thermal Program had additional specific authorities in the Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409) and the "Energy Research Act of 1977" (P.L. 95-39) to undertake research and demonstration of the feasibility of solar thermal use in industrial process heat.

Since the solar thermal and biomass technologies differ considerably in the nature of the necessary research and development and their program objectives, the two program components are treated separately below.

BIOMASS ENERGY SYSTEMS

Program Objectives

Since 1979, the broad goals of this program have been to stimulate the production of an additional 1.5 quads of energy per year from biomass by 1985 and an additional 6 quads per year by the year 2000. The Biomass Energy Systems Program sought to address both the means of enhancing the production of appropriate plant and aquatic life (biomass feedstocks) and improving the efficiency of technologies to convert this biomass into useable energy. The objective of the feedstock research and development was to develop new techniques to increase the production of biomass sources in sufficient quantities to make conversion to fuel economically feasible without disruption of the food or fiber markets. This objective included the development of technologies to provide economic petroleum replacement from aquatic biomass, the selection of the most promising herbaceous species that could be grown for maximum energy yield, and an increase in the annual yields of forestry wood crops from 1.5 to 8 dry tons per acre per year by 1992.

The objective of research and development on conversion technologies was to convert a variety of biomass feedstocks into liquid and gaseous fuels and chemical feedstocks, at competitive costs and in sufficient quantities. This objective included the production of medium-Btu gas and methanol at costs competitive with fossil fuels, the development of anaerobic fermentation technologies to produce biogas at $4 per million Btu's by 1990, and to develop photobiological systems that will produce hydrogen from water and biomass resources.

It is generally accepted that of all the renewable technologies, biomass has the potential to be the largest renewable energy resource during the next 20 years. In 1980, the United States used approximately 1.8 quads of energy from biomass sources, excluding alcohol. The Office of Technology Assessment published a study on biomass in 1980 which estimated that biomass might produce as little as 4 to 6 quads or as much as 12 to 17 quads of energy by the year 2000. The Office of Technology Assessment estimated that substantial increases in biomass use would occur from conversion of wood to other fuels or direct heat.

The activities of the biomass program are carried out in conjunction with other Department of Energy programs. For example, the Office of Alcohol Fuels (which was formerly part of the biomass program) and the biomass program both carry out biochemical research and technology development although they are investigating different products and end-uses. The Department's Office of Energy Research and the National Science Foundation sponsor research in solar hydrogen production that complements biological hydrogen production research under way in the biomass program. The Department's Office of Industrial Programs conducts an Integrated Farm Energy subprogram that tests the use of biomass and other technologies for on-farm systems. The Department of Energy is involved in a cooperative biomass program with the Department of Agriculture to develop near-term woody plant production systems which increase the yields of energy feedstocks as well as food and fiber feedstocks and to develop high-yielding herbaceous plants. The National Science Foundation conducts a basic research program in genetic manipulation and aquatic plant chemistry.

The current goal of the DOE program is to focus on the development of innovative biomass feedstock and conversion techniques thereby expanding the fundamental technology base. This has led to a change in program emphasis away from technologies whose risk and rate of return might be competitive in the marketplace in the near-term and toward long-term, high-risk, and high-payoff research and development. Prior to 1979, the program's research and development emphasized conversion technologies, especially large-scale applications, with very little effort devoted to improving yields of biomass feedstocks. Today, the program is more evenly balanced between work on conversion technologies and feedstock production.

An alternative method for achieving the objectives of the biomass program is to rely on the private sector for biomass research and development.

Program Results

While the Biomass Energy Systems Program has been largely focused on long-term research and development, it has played a role in helping to publicize the availability and desirability of biomass as an alternative fuel. The nationwide use of biomass energy has increased significantly over the last 5 years, primarily in the industrial and residential sectors. Until the mid-1970's, the forest products industry was the only significant user of wood residues for direct combustion. Today, the forest products industry has dramatically increased its use of wood as an energy source, and other industries have begun to burn wood and agricultural residues such as pecan shells and rice hulls. It is currently estimated that the forest products industry alone uses wood supplies to produce approximately 1.2 quads of energy annually in the generation of electricity, process heat, and space heating. While only a portion of this increase is due to the efforts of the biomass program, it is an indication of the potential for the use of biomass.

The feedstock development element of the biomass program focused on short-rotation woody crops, herbaceous energy systems, and aquatic biomass energy systems. During the past 3 years, the biomass program has been evaluating the usefulness of short-rotation woody crop systems for energy feedstocks. Twenty-five promising woody plant species have been identified based on productivity, ease of management, and resistance to pests. Research data obtained from the Department's experimental plots have shown productivity rates of 5 to 9 dry tons per acre per year. By contrast, yields from current species and forestry practices range from 1.5 to 4 dry tons per acre per year.

The herbaceous crops research being conducted by the biomass program has concentrated on increasing the productivity of hydrocarbon plants grown on arid lands and grasses grown on marginal lands. Efforts also are being made to improve existing oil seed crop production systems. In 1979 the biomass program completed its preliminary screening of 280 species to select the most promising herbaceous plants for maximum energy yield. Twenty-six species that produce natural plant hydrocarbons are currently undergoing field research. Field-scale experiments to improve the biomass productivity of the four most promising species selected in the screening phase of the herbaceous research program have shown promising results. Field tests on sugar cane and milkweed, both potential sources of hydrocarbons, indicate significant improvements can be made in crop yields.

The higher risk research on aquatics sponsored by the biomass program has focused on improving microalgal energy systems. Basic screening efforts conducted to date have yielded microalgae of 50-percent oil content with the potential for high growth rates on saline water.

The conversion technology element of the biomass program has focused its research and development efforts on thermochemical conversion technologies, biochemical conversion technologies, and photobiological systems.

Program accomplishments in the area of thermochemical conversion technology include the successful operation of a direct liquefaction facility at Albany, Oregon. Studies completed at this facility have proven the technical feasibility of producing oil from woody biomass. Initial tests of processes for the gasification of wood also have been completed that indicate that medium-Btu gas can be produced at $4 per million Btu's. Investigations sponsored by the biomass program to develop synthesis gas have indicated that methanol can be produced from biomass at a cost of $0.55 per gallon. In addition, results obtained from large-scale furnace tests have demonstrated the utility of retrofitting oil and gas burners to burn wood. Experiments also have established the feasibility of using gases obtained from the wood combustion process to fire gas turbines for electricity generation.

The major program accomplishment in biochemical conversion technology has been the development and operation of an anaerobic digestion test facility designed for a 10,000 head feedlot at Bartow, Florida. This facility, which demonstrated the technical and economic viability of anaerobic digestion systems for animal manure, has been transferred to the private sector. Further test results obtained from the biomass program's experimental on-farm manure digesters for 50 to 500 head dairylots indicate that biogas can be produced at a lower cost than propane or fuel oil.

The biomass program's efforts to develop photobiological systems that will produce hydrogen for fuel and chemical feedstocks have been generally successful. A major achievement has been the successful development of an <u>in vitro</u> cell-free system with high photobiological efficiency.

Except for the potential for increased use of wood resources to cause air pollution in some locations, most of the health and safety impacts of technologies being addressed by the biomass program are small and/or beneficial. Environmental, safety, and health impacts generally can be more favorable for the production and use of biomass energy than for energy from conventional sources.

Projected Program Requirements

The fiscal year 1982 appropriation for this program is $20.5 million. These funds will be used to conduct long-term, high-risk but high-payoff research to provide the technical basis for an increased supply of biomass fuels and feedstocks and for more energy-efficient and cost-effective conversion technologies. Demonstration and commercialization activities have been phased out since they can be accomplished by the private sector.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

SOLAR THERMAL ENERGY SYSTEMS

Solar thermal technologies concentrate and convert the Sun's radiant energy into useable heat energy. This useable heat can be "generated" by collectors (usually concentrating mirror devices such as parabolic troughs, parabolic dishes, central receivers surrounded by mirrors called heliostats, and hemispherical bowls) that focus the Sun's rays to achieve the desired temperatures. Useable heat can also be collected in salt gradient solar ponds. Solar ponds rely on a physical phenomenon related to differences in salinity levels; the pond collects and stores heat in a lower saline layer blanketed by an insulating layer of fresher water.

Depending upon the technique used, the heat output from a solar thermal device can range from 100^{o} to $2,500^{o}$ F. While solar thermal systems were originally thought to have a major application in industrial, agricultural, and commercial processes that require direct (process) heating, their main use may well be to generate steam to make electricity or to produce hydrogen-based fuels.

Program Objectives

The Federal Government has funded research in solar thermal technologies since the 1950's. The current program was established in 1974 pursuant to authority under the Solar Energy Research, Development, and Demonstration Act to "demonstrate the technical and economic feasibility" of solar thermal energy systems. The act set forth functional objectives for the program:

- Production of electricity from a number of 1- to 10-megawatt powerplants

- Production of synthetic fuels in commercial quantities

- Large-scale use of solar energy in the form of direct heat

- Utilization of thermal and all other solar facility by-products

- Design and development of hybrid systems involving the concomitant utilization of solar and other energy sources

- Continuous operation of such plants or facilities for a period of time

P.L. 95-39 added a seventh objective:

- A 5-megawatt demonstration for small community applications

After evaluating the potential of each solar thermal technology in various applications, and realizing that cost was a key barrier to accomplishing the congressional desire for commercial-scale development, the program also developed cost-performance objectives. These were cast in the form of dates by which, with mass production by industry, the cost (in 1980 dollars) of using solar thermal would be the following:

- Industrial process heat--$9 to $11 per million Btu's by the early 1980's
- Total energy/cogeneration--$1,000 per kilowatt (electric and thermal) by 1983-84
- Utility electric power--$1,300 per kilowatt-electric by 1985-87

These cost targets reflect the value of competing conventional energy systems in the Southwest and are deemed achievable. However, the targets are highly sensitive to concentrator production volumes. These targets assume production volumes of about 1 million square meters per year per factory. Table 25-1 details the specific subsystem and component cost goals to meet these cost-performance objectives.

The Solar Thermal Program is the only Federal research and development program for advanced solar thermal energy conversion techniques. In the private sector, the Electric Power Research Institute (EPRI) and the Gas Research Institute are coordinating their efforts with the Federal program. Internationally, the program has supported cooperative agreements with the International Energy Agency, Spain, and France.

The primary alternative to the Solar Thermal Program is to allow the private sector to undertake the research and development on its own and commercialize the results. Financial incentives to the private sector already exist in the form of the business energy tax credit of 15 percent (in addition to the standard 10-percent investment tax credit) and the investment incentives contained in the Economic Recovery Tax Act of 1981 (P.L. 97-34).

Program Results

Significant progress has been made toward meeting the diverse congressional objectives and establishing the technical feasibility of complex systems that can be used both with industrial plants and electrical grids.

The program began developing a technology base before any solar thermal industries existed. Current suppliers still operate on a "customized" basis, but as a result of program efforts, an industry is emerging for one medium-temperature concept--parabolic troughs. This experience suggests that high-temperature concepts--parabolic dish and central receiver--can follow suit. A recent Jet Propulsion Laboratory survey shows that potential suppliers have borne about 25 percent of the solar thermal research and development costs for these technologies.

The following are the major program accomplishments toward meeting the congressional objectives. Table 25-1 highlights accomplishments by objective, budget, and annual activity.

- To produce electricity from several 1 to 10 megawatts-electric powerplants, a variety of facilities have been and are being built. A 150 kilowatts-electric parabolic trough system near Coolidge, Arizona, has been producing electricity reliably for 2 years. A central receiver test facility in Albuquerque, New Mexico, is testing heliostats, storage components, and several receivers; these include a 1,500° F EPRI/Boeing air receiver and a prototype of panels for the 10 megawatts-electric pilot plant under construction near Barstow, California. The Barstow plant, the largest of its kind in the world, will start operations in 1982. Continuous operation would constitute a significant step toward the achievement of commercial-scale solar thermal powerplants. In addition, a detailed conceptual design was completed to establish the feasibility of producing electricity using the salt gradient solar pond technology at the Salton Sea in California.

- Solar thermal technology has been used to produce synthetic fuels in the laboratory on a bench scale. The program investigated a number of potential processes and is now focusing on hydrogen production processes. Establishing technical feasibility of such processes, however, is at least 5 years away, and actual commercial production by the process industry is still further away.

- Large-scale utilization for direct heating in the medium-temperature (200° to 500° F) range, where 30 percent of industrial process heat is used, has been accomplished in several experiments using parabolic trough collectors. This experience identified several areas of needed component research and development and proved that parabolic trough technology was nearly ready for commercialization by industry. For the high-temperature range (500° to 1,500° F), where an additional 35 percent of all industrial process heat is used, central receiver systems are deemed best-suited for large-scale applications. Such systems have been designed, but neither a system nor its major components, such as tower-mounted receivers, have ever been tested in a configuration that meets the specifications of direct heat applications.

- A cogenerating plant makes use of thermal and all other solar facility by-products. Using parabolic dish technology, such a total energy project at Shenandoah, Georgia, will start operation in 1982. This first-of-a-kind field test will simultaneously produce electricity and industrial process heat.

- The development of hybrid (solar-fossil) systems and demonstration of small community applications is important for remote power applications, as well as small community applications. To that end, versions of both Brayton and Stirling engines for use with parabolic dishes in a solar/fossil hybrid mode are well along in the development cycle; and the program has completed a preliminary design for a 0.25 megawatt-electric to 1 megawatt-electric dish system, aimed at small community needs.

Program benefits are anticipated to accrue in the electricity sector where solar thermal can displace increasingly expensive conventional fuels (petroleum and natural gas) and potentially reduce operations and maintenance costs. In the long term, the United States will benefit from reduced dependence on foreign oil.

Environmentally, solar thermal systems emit less air pollutants than conventional systems and can enhance industrial growth in areas restricted by air pollution standards. In the long term, atmospheric CO_2 buildup could be reduced. Health and safety dangers appear minimal.

Projected Program Requirements

Congress has appropriated $55.0 million for fiscal year 1982. The program will continue to address long-term research and development needs that now preclude the industry from developing cost-competitive solar thermal systems. The program will phase out its previous activities in the demonstration and commercialization of the solar thermal technologies. During fiscal years 1982 and 1983 the program should complete the 10 megawatts-electric central receiver system operation and provide research and development support for industry initiatives in central receiver scaleup/repowering; complete near-term trough research and development, and transfer that technology to the industry; field test industrial parabolic dish designs in user environments at a meaningful scale to prove technical feasibility; and, research the technical feasibility of bulk hydrogen production processes. These and other future program activities are outlined in Table 25-2.

Funding variations of plus 10 percent or minus 10 percent might accelerate or delay, by a few months, progress toward achieving the cost and performance objectives.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(26) WIND AND OCEAN SOLAR POWER TECHNOLOGIES (CE)

The Solar Power Technology Program sponsors research and development of two solar-related technologies having potential applications in utility systems. The two technologies--wind energy systems and ocean energy technology--differ in the degree to which they are developed technically and the extent to which the private sector has commercialized them. As a result, the focus of each subprogram differs. Since wind systems already are being sold commercially for special applications, the wind program is directed toward reducing the cost of wind technology to enable it to compete with conventional energy systems. In contrast, the ocean energy technology program has focused on establishing the technical and economic feasibility of the technology.

Federal involvement with wind energy systems and ocean energy technologies began with small-scale programs which were intensified after the passage of the Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473). Congress established quantitative goals for both of the technologies in 1980.

Because of the differences in these two technologies, especially the degree to which each is developed, the two subprograms are discussed separately below.

WIND ENERGY SYSTEMS

Program Objectives

The Wind Energy Systems Act of 1980 (P.L. 96-345) directs the Department of Energy "to establish during the next 8 years an aggressive research, development, demonstration, and technology applications program for converting wind energy into electricity and mechanical energy" to attain the cost and production goals cited in the act. The goals of the Wind Energy Systems Program as established by the Wind Energy Systems Act are to conduct a technology program which, by 1988, will reduce the average cost of wind-generated electricity to a level competitive with conventional systems; will enable the Nation to reach a total wind energy system capacity of 800 megawatts-electric; and will accelerate the growth of a commercially viable and competitive wind industry. Based on current economics, the cost of electricity would have to be approximately 3 cents to 6 cents per kilowatt-hour for large systems and 5 cents to 10 cents per kilowatt-hour (1980 dollars) for small systems to be competitive. Historically, the program objectives to achieve these goals have been as follows:

- To develop and test systems to prove the feasibility of large systems and to improve the reliability and economics of small systems

- To develop analytic methods to improve siting, design, and operation of wind systems

- To promote market development of large and small wind systems

- To fulfill the goals of the Wind Energy Systems Act

Federal involvement in a wind energy program began in the early 1970's with a small technology development program at the National Science Foundation. In 1974, the program was transferred to the Energy Research and Development Administration (ERDA) under the Solar Energy Research, Development, and Demonstration Act. ERDA was provided with increased authority under the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577). With the establishment of the Department of Energy in 1977, the Federal wind energy program expanded to address all aspects of wind energy conversion system development, including research, development, and demonstration as well as nontechnical and commercialization support activities.

Several Government agencies contribute to the Federal wind energy program. The Department of Energy funds research and development. The Bureau of Reclamation in the Department of the Interior is installing two large wind turbines for testing at Medicine Bow, Wyoming. The Bonneville Power Administration is host for an experimental three-unit cluster of Department-funded wind turbines. The Department of Transportation is cooperating with the Rocky Flats Test Center to test small wind turbines on a controlled velocity test facility track. The Departments of Agriculture and Defense are participating in operational experiments and test applications of small wind machines. Alternatives to the DOE wind program could include transfer of some or all activities to other Federal agencies or reliance on the private sector to conduct wind research and development.

Program Results

Program objectives have been achieved through broad, comprehensive research, development, and demonstration efforts. Small wind machine prototypes have been field tested in seven states and small commercial machines have been installed in 24 states. Thus far, the industry has achieved small wind turbine electricity costs of 8 cents to 15 cents per kilowatt-hour, depending on machine design, operating conditions, and production quantity.

Thirteen large wind turbines (greater than 100 kilowatts), eight of which are Department funded, have been installed for a total rated output of nearly 20 megawatts. The Department of Energy has sponsored a 2-megawatt system (MOD-1) at Boone, North Carolina, and 200-kilowatt systems (MOD-OA) at Clayton, New Mexico; Culebra, Puerto Rico; Block Island, Rhode Island; and Oahu, Hawaii. The Bonneville Power Administration is the host utility for operating the experimental cluster of three of the largest wind turbines in the world (the 2.5-megawatt MOD-2). Wind technology has improved to the point where at least five public utilities are considering large "wind farms" in their planning for future capacity. The estimated cost of electricity from large wind machines (that is, MOD-2 in production) has been reduced to 6 cents to 10 cents per kilowatt-hour. Moreover, several hundred companies throughout the country have participated in wind system research and development.

The use of wind energy systems to generate power is expected to have less of an impact on the environment than using fossil fuel or nuclear systems. Audible noise and television interference are potential environmental concerns which may be eliminated through careful design and siting.

From fiscal year 1977 through fiscal year 1981, annual funding for the Federal wind energy program has more than doubled. The small wind system industry in the United States has grown from an industry producing dozens of machines per year to one producing several thousand machines per year. The large wind energy system industry, nonexistent in 1977, has begun to penetrate the utility power generation market. While some mechanical problems and operating deficiencies characterize certain large wind machines, the Department's technical research and development program has improved the efficiency of machine designs and reliability of subsystem components. Field activities have increased consumer interest and confidence in wind-generated electric power and, have improved, therefore, the viability of a competitive wind system industry in this country. Major past accomplishments and current objectives of the Federal program are outlined in Tables 26-1 and 26-2, respectively.

Projected Program Requirements

The Federal wind energy program and the private sector have shared in the development of a technical base and an institutional framework that have improved the competitive position of the wind system industry. Continuing Federal support will emphasize high-risk research and development, including the testing of advanced prototype machines and research on component improvements.

Congress has appropriated $35.4 million for the wind program in fiscal year 1982. These funds will provide support for small and large machine technology base research, will continue reliability and operational testing of previously developed large machines, and will sustain ongoing research in wind characteristics. In fiscal year 1983, the program is expected to continue the small and large machine technology base research and development on wind characteristics and to terminate machine operational testing (on the assumption that the machines can be turned over to host utility operators).

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

OCEAN ENERGY TECHNOLOGY

Program Objectives

The Department of Energy's ocean energy technology program seeks to determine the potential of and increase the utilization of the renewable energy generated by the oceans. Energy can be captured from ocean waves, currents, and salinity gradients, and, most importantly, by exploiting the thermal gradients that occur between different depths using a process called ocean thermal energy conversion (OTEC). Historically, the goal of the ocean energy technology program was to promote the development of ocean energy systems primarily through research and development of methods for extracting and distributing ocean energy in a cost-effective, reliable, and environmentally acceptable manner. The Ocean Thermal Energy Conversion Research, Development, and Demonstration Act of 1980 (P.L. 96-310) annunciated certain quantitative goals.* The programmatic objectives developed to obtain these goals include the following:

- Provide the first estimates of the potential of the ocean thermal resource and assemble resource and environmental data required for site selection and plant design

- Perform research and development aimed at technology improvements that reduce technical risk and improve performance sufficiently to permit the private sector to construct ocean energy systems

- Promote market development for diverse classes of ocean energy systems by increasing user awareness and acceptance, by encouraging expansion of manufacturing capabilities, and by reducing barriers to commercialization

- Testing industry concepts for OTEC technologies and disseminating research and development information developed by the program

The Ocean Thermal Energy Conversion Act of 1980 (P.L. 96-320) establishes a one-stop licensing authority administered by the National Oceanic and Atmospheric Administration and makes OTEC plants and plantships eligible for construction loan guarantees administered by the Maritime Administration. In addition, the Crude Oil Windfall Profit Tax Act of 1980 (P.L. 96-223) provides an energy tax credit of 15 percent (in addition to the existing investment tax credit of 10 percent) for OTEC plants in two locations.

Program Results

Progress has been made toward the attainment of OTEC program objectives; however, ocean power technology has not been commercialized. Information about the potential of the resource (which is highly dependent on the efficiency of the technology) has been developed. Site-specific OTEC resource data have been obtained from satellite imagery, surveys, and onsite

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*The Ocean Thermal Energy Conversion Research, Development, and Demonstration Act established the following national goals: demonstration of at least 100 megawatts-electric of OTEC capacity by 1986; demonstration of at least 500 megawatts-electric of OTEC capacity by 1989; production of OTEC energy that is competitive with the cost of energy from conventional sources for the U.S. Gulf Coast and the U.S. Islands; and installation of 10,000 megawatts-electric of commercial capacity by 1999.

measurements for locations in the Gulf of Mexico, the South Atlantic, and off the coasts of Puerto Rico and Hawaii. Ten world site studies based on archival data have also been completed and a worldwide thermal resource map has been constructed from existing data. An initial study of OTEC potential estimated that 18.8 to 38.4 quads per year are available in the Gulf of Mexico, Puerto Rico, and the Hawaiian Islands.

Conceptual design studies have been completed for six different OTEC plant configurations, and conceptual and preliminary design studies have been conducted on the cold water pipe, power systems, electrical cable systems, and mooring and positioning systems. Technical feasibility of a complete OTEC power generation system has been demonstrated by Mini-OTEC, a 50-kilowatt-electric gross (10-kilowatt-electric net) experimental vessel funded by private industry and the State of Hawaii. The technical feasibility of OTEC components (ammonia and water subsystems) has been proven in larger scale ocean-based test programs. The OTEC-1 sea-based engineering test facility demonstrated the reliability of large-size heat exchangers.

The ocean program has developed an understanding of the economic, institutional, and commercial factors that will affect OTEC integration into potential markets, including the electric power, synthetic fuels (methanol), aluminum, and ammonia industries. Decision-makers in these possible user communities, as well as potential OTEC producers (such as shipbuilders and component manufacturers), indicate that there are no major institutional barriers to early industrial development.

Since the ocean energy program expenditures are relatively small, their impact on the national economy is limited. Nevertheless, several hundred companies throughout the Nation have participated in OTEC research and development.

The net environmental impacts from OTEC development are expected to be less detrimental than the impacts associated with other baseload power sources. However, there is concern that OTEC could have some adverse effects on the ocean environment. Of primary concern is the marine ecosystem, because ocean water is the source of the evaporating and condensing waters for the plant as well as the receiver of OTEC plant effluents. Studies of the impingement and entrainment of marine biota on heat exchanger surfaces, ocean water mixing, sea surface temperature perturbations, biocide release, and working fluid leaks have been conducted in an effort to reduce the uncertainty about the environmental effects of OTEC development.

Projected Program Requirements

While OTEC holds the promise of being a cost-effective renewable source of electricity, especially for the island economies, a commercial-sized plant has not been built in the United States. The Japanese have built a 100-kilowatt plant for the island of Naaru. Several other foreign countries have expressed interest in pursuing this technology, and several U.S. firms have expressed interest in building a pilot plant. The Administration believes that the cost of any commercial-size plant should be borne by the private sector. The fiscal year 1982 appropriation of $20.8 million for OTEC will support the orderly termination of the research program. No funding will be requested in fiscal year 1983 for this program.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(27) SOLAR INFORMATION, INTERNATIONAL, AND SERI (CE)

The programs covered in this section include the Solar Information Systems, the International Solar Energy Program, and construction of a permanent facility for the Solar Energy Research Institute (SERI).

SOLAR INFORMATION SYSTEMS

Program Objectives

The Solar Information Systems Program is designed to share the results of DOE renewable energy programs with other Federal agencies, state and local governments, and the private sector. The program has centered around the operation of a Conservation and Renewable Energy Information Network. A key participant in the network is the Solar Energy Research Institute (SERI), which has lead responsibility for preparing technical information products and maintaining the information network. DOE headquarters provides managerial oversight and program guidance. The network relies upon the bibliographic and abstracting services of DOE's Technical Information Center in Oak Ridge, Tennessee. The legislative mandate for the program includes section 8 of the Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473); section 12 of the Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409); section 101 of the Energy Reorganization Act of 1974 (P.L. 93-438); section 509 of the National Energy Extension Service Act of 1977 (P.L. 95-39); and section 404 of the Energy Security Act of 1980 (P.L. 96-294).

The broad goal of the program is to transfer the results of relevant solar energy research and development to energy users through an integrated national network, and to coordinate the solar energy information activities within the Department and with other Federal agencies in order to avoid duplication of effort.

Historical program objectives included establishing and maintaining solar energy data bases and preparing information products based on user needs; increasing the use of solar energy products; responding to client inquiries; sponsoring workshops and seminars to disseminate solar information; and coordinating Federal solar information activities. The degree to which these objectives have been met is shown in Table 27-1. Current objectives are shown in Table 27-2.

Much of the enabling legislation for the Solar Information Systems Program grew out of the desire to accelerate the use of solar energy and the belief that a solar energy information network was necessary to the widespread support of the national solar program.

There have long been a number of solar-related information programs with similar objectives and with some overlap. In earlier years, the Federal

Government provided a wide range of fairly general information on solar technologies. Today, however, there are many other readily available sources of generalized data; and the current Federal strategy emphasizes meeting the detailed information needs of high-priority users, such as the research and development community, the financial sector, equipment manufacturers, architects, and engineers.

Program Results

The Department's Solar Information Systems Program has had considerable success in transferring the results of relevant research and development to energy users through an integrated national network, and also in coordinating the solar energy information activities of DOE and other Federal agencies. Since the program began, more than 1 million people have been provided with timely and accurate solar information. The information disseminated through DOE workshops, seminars, and mail-outs in response to inquiries has contributed to the widespread acceptance of various solar technologies.

The availability of easily accessible information about solar technologies has helped manufacturers and builders increase their sales; builders and buyers have been able to obtain larger loans because more bankers understand now how to appraise a solar energy system; community and business groups have been able to conduct seminars because material was available that they could readily adapt for their purpose; homeowners have been able to use information to build and buy solar energy systems; and members of the scientific and research community have been able to use the latest solar research results to enhance their own efforts.

Program accomplishments are specifically summarized in Table 27-1.

Primary users include the research and development community, architects and engineers, trade associations, state and local organizations, consumers, universities, and other members of the private sector. The inquiry and referral system is currently handling about 2,000 inquiries per week.

Projected Program Requirements

For fiscal year 1982, $6.7 million has been appropriated for the program. A 10-percent funding increase would permit development of additional technical information products to meet users' demand. In addition, the program could be expanded to include technical information on a broader spectrum of renewable energy technologies. A 10-percent decrease would result in a reduction in the number and types of information products.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

INTERNATIONAL SOLAR ENERGY PROGRAM

Program Objectives

The goal of the International Solar Energy Program, which is considered here as a unit, has been to accelerate the development and use of solar energy technology in the United States and worldwide, through joint projects with cooperating foreign countries and through international information exchange and market development. Some of the joint projects are located in this country, others are outside the United States.

Congress has passed 16 different public laws providing legislative authorizations for the Department of Energy to engage in international solar energy activities. These include cooperation with other nations in research and development and with other U.S. institutions engaged in international programs. Principal legislative authority is derived from the Solar Energy Research, Development, and Demonstration Act; the Energy Reorganization Act; and the Department of Energy Organization Act of 1977 (P.L. 95-91).

In keeping with the current Department policy of concentrating technology programs primarily on high-risk, long-range research and development, international market development activities were phased out in fiscal year 1981. Current emphasis is on completing bilateral and multilateral international research projects, encouraging the international acquisition and dissemination of research and development information, and obtaining maximum benefits from such cooperation and exchanges for domestic research and development programs. The Department is continuing international activities relating to solar technologies under the International Energy Agency (IEA), the United States/Saudi Arabia agreement, and other cooperative agreements that involve solar technical assistance to U.S. Government agencies and to international organizations engaged in renewable energy activities.

The historical objectives of the International Solar Energy Program are shown in Table 27-1. Table 27-2 gives current program objectives.

Program Results

Considerable experience in system design and operations has been obtained through joint research and development programs with foreign countries. In general, the cooperative projects involve private industry in cost-sharing or task-sharing arrangements; and they are directed toward filling domestic program gaps and obtaining operational experience.

Under a multilateral IEA agreement with eight other countries, construction was completed in 1981 on two 500 kilowatt-electric solar thermal systems of different types, both located in Almeria, Spain. They will give the United States operational experience with a distributed collector system and a central receiver system using high-flux sodium. Two U.S. companies played leading roles in carrying out the project, and this country contributed 18 percent of the total project cost of about $40 million.

Under a bilateral agreement, the United States/Saudi Arabia SOLERAS project has provided for the construction of a 350 kilowatt-electric photovoltaic village power system in a remote arid region. It is providing experience in the operation of a large photovoltaic concentrator in an area where no conventional power backup is available. The project was carried out by U.S. companies, and the United States contributed half of the total project cost.

Other program accomplishments are shown in Table 27-1.

There have been many direct beneficiaries from these international cooperative projects, including solar research and development program organizations in the United States, the U.S. solar industry, the foreign governments promoting the use of solar technologies, and cooperating foreign institutions. Information acquired through such efforts has helped the U.S. solar industry to maintain a competitive edge in overseas markets. Although solar export trade has been relatively small to date, it currently represents a noticeable share of production of both active solar and photovoltaic collectors and can be expected to increase. This should have a positive effect on the U.S. balance of payments, aid the development of a stronger industrial base within the United States, and reduce the cost of domestic solar systems. In the long term, broader application of solar energy around the globe can reduce worldwide dependence on oil and natural gas.

Projected Program Requirements

Congress has appropriated $4.0 million for fiscal year 1982 primarily to meet the obligations of the SOLERAS agreement. A number of lesser priority projects are being reduced in scope or terminated as appropriate. Funding beyond fiscal year 1982 will allow an orderly completion and phaseout of current bilateral and multilateral agreements, including the Saudi SOLERAS agreement.

A further reduction in fiscal year 1982 funding of 10 percent would reduce the scope of the SOLERAS project or eliminate it completely. An increase in funding of 10 percent would help ensure that SOLERAS commitments are completed.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

SOLAR ENERGY RESEARCH INSTITUTE FACILITY

Program Objectives

Establishment of the Solar Energy Research Institute was authorized by the Solar Energy Research, Development, and Demonstration Act. The Midwest Research Institute, selected through a competitive solicitation to operate

SERI under contract to the Department of Energy, began SERI operations in July 1977 in leased buildings.

SERI occupied leased space in four buildings. In 1977, the State of Colorado offered the Federal Government 300 acres of adjacent land for the construction of a permanent SERI facility. The Department agreed in November 1981 to accept the state's land gift, indicating that it will be used at least as a field experiment area, including a support building.

The original objective was to design and construct permanent facilities for approximately 1,000 SERI employees, many of whom were engaged in non-research activities. Part of the original intention was to demonstrate the economic, environmental, and aesthetic use of energy conservation and renewable energy technologies within the facility itself. Recently, DOE has reduced SERI's scope and redirected its role to focus primarily on high-risk, long-term research and development. As a result of this change, the composition of the staff was changed and the number of positions reduced. Therefore, the current objective is to construct the new test site and support building and continue to lease space for some SERI employees.

Program Results

Part of the prior year appropriations of $14.9 million has been expended for initial design and redesign. Approximately $10 million in remaining unobligated funds will be used for construction of a test site and laboratory building.

Projected Program Requirements

Under SERI's revised role and mission, its staff has been reduced in size and changed in composition. No further consideration is being given to the construction of a permanent facility for personnel who do not require direct access to laboratory space. No additional fiscal year 1982 funding was appropriated, nor will any be requested for fiscal year 1983.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(28) ALCOHOL FUELS (CE)

More than half of the petroleum used in the United States is consumed in transportation, and about half of that goes into gasoline for automobiles. This explains the recent national interest in reviving the old idea of using either ethyl or methyl alcohol as automotive fuel--providing a total or partial substitute for gasoline.

The chemistry of producing alcohol fuels is rather simple. They can be made from grain or from a great variety of plant waste materials by using either fermentation processes or direct synthesis. The greatest difficulty is that the manufacture of alcohol fuels has been too expensive for them to compete with gasoline unless they were subsidized heavily (for example, by rebating the full excise tax on motor fuel mixtures that contain as little as 10-percent alcohol). Primarily for that reason, production and use have lagged.

Program Objectives

The goal of the Office of Alcohol Fuels is to promote the cost-effective production, distribution, and use of alcohol fuels without impairing the Nation's ability to produce adequate supplies of food and fiber, thus providing a renewable, domestically produced alternative to imported fuels.

This office receives its mandate from Title II of the Energy Security Act of 1980 (P.L. 96-294); and it now has jurisdiction over all DOE programs dealing with alcohol derived from biomass. Prior to the establishment of a separate Office of Alcohol Fuels in February 1980, activities relating to alcohol fuels had been carried out in several parts of DOE; and most of the cellulose-to-alcohol research program had been funded under the Department's Biomass Energy Systems Program (see PAU #25, "Solar Applications for Industry"). DOE's Biomass Program still sponsors research and development in feedstock development, as well as on nonalcohol fuels from biomass. The Department of Agriculture also is involved in the general effort, by making loans available to small- and intermediate-sized alcohol producers who qualify for Business and Industry loans under the Farmers Home Administration.

Under the authorization of the Energy Security Act, the Office of Alcohol Fuels may provide loan guarantees to companies using present-day technology to convert starch or sugar into alcohol fuels. The program also focuses on important, high-risk research and development opportunities relating to alcohol fuels technologies that are not being addressed by commercial enterprises. The office performs these functions under the broad research mandates of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), as well as the Energy Reorganization Act of 1974 (P.L. 93-438), and the Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473).

Goals, accomplishments, and budget authority for the 2-year history of the Office of Alcohol Fuels are included in Table 28-1. A high level of risk still prevents private enterprises from pursuing certain essential research and development in alcohol fuels. For example:

- Biomass processing techniques need to become more cost efficient, and the profitable utilization of by-products will probably have to become a reality in order to make any alcohol fuel economically competitive.

- The current cost of producing methanol from biomass is too high to consider commercial-scale ventures.

- Cellulose-to-ethanol conversion processes also are too inefficient and expensive to be used for commercial production at present.

- Improvements are needed in the utilization efficiency of both methanol and ethanol, each of which has fewer Btu's per gallon than gasoline.

The Office of Alcohol Fuels will continue to monitor the tax and loan incentives. Loans authorized previously still are being negotiated. Current objectives focus on long-term improvements in process technologies in the following areas:

- Methanol from wood--oxygen-fed wood gasifier of downdraft design and advanced gasifier designs

- Fermentation of alcohols from cellulose--pretreatment, acid hydrolysis processes, enzymatic hydrolysis process, product separation, and genetic engineering

- Utilization technology--dissociated alcohol combustion engines and multifuel and hybrid engines

- Supporting research and development--improvements in process economics to improve product worth and by-product use

Section 24 of the Energy Security Act established production and use goals for alcohol fuels (including gasohol, which is a mixture of 90-percent gasoline and 10-percent alcohol) of 60,000 barrels per day (approximately 920 million gallons per year) by the end of 1982. Its production and use target for 1990 was an amount of pure alcohol equal to 10 percent of all gasoline consumption at that time (estimated to be 84 billion gallons per year), almost a tenfold increase in fuel-alcohol production over the next 8 years.

The first Energy Security Act goal was not realistic, and will not be reached. Even with considerable Federal encouragement, subsidy, and promotion, current production of alcohol used as fuel is only about 2,800 barrels per day (approximately 43 million gallons per year, or less than 0.01 quad).* Nevertheless, the stimulation provided by the financial incentives program has been substantial. Loan guarantees now are being negotiated for 10 projects whose combined output would be 350 million gallons per year. It is not likely that all 10 projects will be successful, and none of the projects will be complete before 1984. Although the 1990 goal cannot be ruled out, its attainment will depend on market factors as well as a number of research and development breakthroughs.

Program Results

Although the Office of Alcohol Fuels has been in existence only a short while, the record suggests modest success. By 1983, some degree of financial assistance will have been provided to stimulate the construction of plants whose annual production capacity will be 440 million gallons of alcohol (about 0.1 quad per year). Furthermore, although costs are still high, research and development has aided industry in working toward the goal of profitably utilizing cellulosic materials as a major feedstock. Efforts under the research and development program included the following:

- In work on biotechnology, a fungus was identified that hydrolyzes and ferments both cellulose and xylose (wood sugar). Also, a clostridium bacteria system was developed for producing ethanol from corn stover (residue), and the same system has been shown to be applicable to honey locust and mesquite pods rich in carbohydrate. In some cases, a fermentation process can be improved if a type of sugar within the feedstock (called pentose) is utilized, but this takes place only when certain genes are present. Mutants incorporating such genes were isolated and successfully transformed by genetic engineering.

- In pursuing research and development on processes, kinetic data have been compiled for acid hydrolysis of poplar wood. A new computer model to simulate acid hydrolysis processing also has been developed and is operational. In the fermentation process, it is not necessary to use a vat-type "cooker," in which enzymes move about freely with the feedstock. Especially in cases where the activating cells are very costly, it has been shown that it may be more efficient to keep them in a fixed position and move the feedstock past them. An evaluation was made of how variations in design and operation affect the overall end result, and the findings led to the design of a tubular fermentor in which the cells are immobilized.

- Alcohol can also be synthesized from feedstocks. In this connection, tests have been completed at atmospheric pressure on an oxygen-fed wood gasifier, using 1/8" and 3/8" wood pellets, to determine optimum operation and conditions.

- Finally, there has been research to make alcohol itself a more useful fuel. Here the most fruitful results have come from "dissociated methanol systems," in which the basic fuel is split into separate gaseous components (hydrogen and carbon monoxide)

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*When used in a 10-percent mixture with gasoline, a gallon of alcohol is assumed to produce the energy equivalent of a gallon of gasoline.

before combustion actually takes place. The mapping of engine performance has been completed for such a system, and dynamometer readings showed that methanol handled in this way could outperform gasoline by from 35 percent to 100 percent. The concept is still in its preliminary stages, but road testing has begun now on a vehicle powered by a dissociated methanol system.

The widespread use of alcohol fuels for transportation should have little effect on health and safety as compared with gasoline use. The Environmental Protection Agency has suggested that 100-percent alcohol use would probably result in a slight increase in ozone levels but also a more-than-proportionate decrease in carbon monoxide. Other emissions, such as alcohol and aldehydes, are less photoreactive than gasoline emissions and thus are less likely to contribute to smog.

Table 28-2 provides details on current program objectives and summarizes future budgetary requirements.

Projected Program Requirements

Congress has appropriated $10.0 million for fiscal year 1982 reflecting the elimination of market development activities. A reduced level of funding will be requested for fiscal year 1983. This level of funding will contribute to the technology base for efficient, economically competitive alcohol fuels production and use since it will focus on the high-risk, high-payoff areas of research and development.

Financial support in the form of funded feasibility studies and cooperative agreements has ended. Private-sector programs that received such support are being monitored, but no new funding is planned in 1982. No-year funding of $271.0 million has been appropriated for the loan guarantees, which now are being negotiated and could be finalized during 1982.

A 10-percent decrease in the alcohol fuels budget would cause a disruption by further accelerating what is already a phasedown of program activities.

A 10-percent budget increase would be applied to the area of enzymatic hydrolysis or advanced engine research. Such a project would be short-term in nature and, therefore, incompatible with the administration's long-term research and development policy.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(29) HYDROPOWER (CE)

Although hydroelectric generation is a well-developed technology that normally has supplied more than 3 quads of U.S. energy annually for a number of years,* it has been confined almost entirely to large installations such as those operated by the power marketing administrations (see PAU #47). As recently as the mid-1970's, few small sites were able to compete with central-station thermal plants. Interest in developing or reactivating such sites has been based on the twin concepts that they may individually represent "appropriate" technology for satisfying energy needs in some areas and that they may be economically competitive with oil-based electric generation facilities and may therefore displace imported oil.

Program Objectives

The Small Hydropower Program was begun in 1977 as part of the multifold efforts to lessen dependence on foreign oil. The program is conducted under the authority of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), which authorized such research and development. The Public Utility Regulatory Policies Act of 1978 (P.L. 95-617) authorized loans for feasibility studies, licensing, and construction costs for small hydro projects.

Because hydropower technology in general is mature, the program strategy has been for the Federal Government to "step in" to help reawaken the industry by mitigating technical, legal, institutional, and environmental barriers particularly associated with small hydro, and then to "step out," leaving broad development to non-Federal sectors. Demonstrations and loans were used to stimulate near-term developer activity, but rising costs of energy alternatives are expected to be the stimulus for continued development.

The basic historical goal has been to reestablish a vigorous small hydro industry in the United States. Supporting objectives were to demonstrate the current commercial feasibility of small hydropower; to provide loans that would encourage developers by assisting with preconstruction costs; to directly assist the placement of 1,000 megawatts of new capacity on line or under construction by 1985 through the demonstration, loan, and technical assistance programs; to reduce the costs of small hydro development through research and development on new techniques for retrofitting existing sites

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*Hydro output varies from year to year, primarily because of differences in precipitation; and total U.S. consumption dipped below 3 quads in 1977. About 93 percent of all U.S. hydropower originates in this country, but electricity imported via interconnections with Canada also includes a substantial amount of hydroelectricity that is customarily counted as such in U.S. energy consumption statistics.

and ultra low-head sites and on environmental barriers; to mitigate and help states to mitigate legal, institutional, and technical barriers; and to develop and disseminate technical information to interested developers. Additional details are provided in Table 29-1.

Several other Federal agencies have programs that affect small hydro development--for example, the Federal Energy Regulatory Commission, the Corps of Engineers, and the Bureau of Reclamation. None duplicates the Department of Energy's program.

The alternative to the Federal hydropower program would be continued reliance on the private sector for further development.

Program Results

The basic Department goal has largely been met, as evidenced by the dramatic increase in applications to the Federal Energy Regulatory Commission (FERC) for permits for small hydro operations since this program was initiated. FERC staff estimate that 1,900 applications were received in 1981, compared to 600 for 1980 and a total of 130 for the previous 4 years. Interim objectives of the demonstration program also have been met, with six projects (totaling 17 megawatts) on line and nine others under way--all serving as useful test cases of development barriers. Five other projects are still in the licensing stage. Funding has been provided for the full Federal share of all 20 projects, which will bring 133 megawatts of small hydroelectric generating capacity on line by 1985.

The loan program was operational for less than 1 year, but it helped to stimulate considerable developer interest, particularly by municipalities and other nonprofit entities. It is too early to determine how many of the 170 loan-assisted projects will reach the construction phase in the near future.

Overall DOE administration of the small hydro loan program was effective in carrying out congressional intent. This intent was to stimulate interest and help developers with front-end financing for feasibility studies and licensing costs for high-risk ventures that involve many unknowns during early stages. The program's success is evidenced by the number of such developers who have been assisted. Nevertheless, there is no sure way to identify the number of such developers who might have undertaken studies or licensing procedures without the loan program.

The principal direct beneficiaries under the Small Hydropower Program through fiscal year 1981 have been the 20 demonstration project developers and approximately 225 developers who received support for feasibility studies. In addition, many recent, current, and future developers can benefit from the resource assessments that were assisted by Department funding. Grants have been provided to a total of 40 states for a variety of purposes, including resource assessments, developer workshops, and institutional reforms.

Technical assistance also has been provided to 24 state legislatures and 16 public utility commissions. Dozens of technical reports on generic and state-specific problems have been provided to assist developers, the states, and the Federal Energy Regulatory Commission (FERC). Further details are given in Table 29-1.

The current and potential contribution to the national economy from small hydro is modest but significant (only about 0.05 quad per year at present, projected to rise to 0.2 quad by 1990 and perhaps 0.5 quad by 2000). FERC estimates that by 1995 up to 20,000 jobs and $300 million of electric energy will be created annually through small hydro development. The DOE program helped to improve the relative competitive position of small hydro and to enlarge the number of individual developers. Hydropower provides a significant portion of energy supply in some regions, contributing to their economic stability.

Overall, the development and redevelopment of small hydropower projects probably will have little effect on the quality of the human environment, although there could be significant localized impacts (both positive and negative) from some specific projects. Adverse effects might result from increased water turbidity or the release of toxic substances, either during construction or during operation. Other possible problems involve fish passage around dams (both upstream and downstream), fluctuations in reservoir water level in cases of seasonal drawdown or daily store-and-release operation, and possible deterioration in water quality because of changes in dissolved oxygen, temperature, and chemical content. Trade-offs among land and water uses are almost unique to each site; their optimization may be affected by flow needs downstream from the reservoir or by management of both power and aesthetic values for an entire river basin.

Environmental and health aspects of small hydro (as well as measures for mitigating undesirable impacts) are evaluated in a series of Oak Ridge National Laboratory Technical Manuals, titled "Analysis of Environmental Issues Related to Small-Scale Hydroelectric Development (I through VIII)," which were initiated and funded under the small hydro program. The safety aspects of all hydropower projects, both large and small, are the responsibility of the Corps of Engineers; and that group's program to improve dam safety is a concurrent aspect of small hydro redevelopment. Since recent dam failures in Idaho and Georgia, the Corps has been very active in improving dam safety throughout the Nation. In fact, several of the hydro retrofit developments now under way are the result of the Corps' requirement that particular structures either be breached or upgraded.

The type of hydropower responsibilities the Department has exercised could be handled by the Federal Energy Regulatory Commission, the Corps of Engineers, or the Department of the Interior or Commerce.

Projected Program Requirements

Congress appropriated $3.0 million for the Department's Hydropower Program in fiscal year 1982. No funds will be requested for fiscal year 1983 or beyond. The 20 demonstration projects have been fully funded. The fiscal year 1982 funds will provide for minimal monitoring of these demonstration projects (see Table 29-2).

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(30) GEOTHERMAL RESOURCES (CE)

Geothermal energy consists of natural pockets of subterranean heat that are close enough to the Earth's surface for their high temperatures to be useful. When large amounts of such energy are accessible, geothermal energy may be utilized either in the generation of electricity or in direct-heat applications. Although geothermal energy is not really "renewable" (being derived principally from the gradual but inexorable decay of radioactive materials within the Earth), its ultimate supply is large enough to be considered inexhaustible in the foreseeable future.

The three principal types of geothermal resources in the United States (in order of their technological readiness for application) are hydrothermal reservoirs; hot, geopressured brine; and hot dry rock.

Hydrothermal reservoirs contain hot water and steam trapped in geological formations relatively close to the surface. Geopressured reserves are hot water aquifers that are kept under high pressure at greater depths in the Earth by the natural gas dissolved in the brine. "Hot dry rock" is the term applied to formations at drilling-depth that have abnormally high heat content but contain little or no water.

The total contribution of geothermal energy in this country during 1980 was about 0.05 quad. The geothermal industry presently comprises a relatively small number of corporations--the most significant of which are the energy companies and utilities. In the areas where it is being used, geothermal energy is more economical than any available commercial fuel.

Program Objectives

The historical goal of the Department of Energy's program has been to increase the use of geothermal energy resources as reliable, operationally safe, environmentally acceptable, and economically viable alternative energy sources--both for electric power production and for direct heat. Through fiscal year 1981, the program sought to reduce uncertainties about the dimensions of geothermal resources (which had not been explored very thoroughly) and also to remove some key technological, economic, and institutional impediments that had inhibited their commercial development. The program objectives pursued during fiscal year 1978 through fiscal year 1981 are shown in Table 30-1. They addressed risks perceived by the private sector in the area of reservoir capacity and longevity, the high cost of field development, the economics of commercial-scale plants, environmental effects of production, and promising technologies for energy-extraction and conversion that remained unproven.

Currently, the major thrusts of the program are to conduct research and development directed toward reducing the risks in all aspects of fluid handling associated with the use of high- and moderate-temperature* hydrothermal resources; and to determine the technical feasibility of extracting energy from geopressured and hot dry rock resources.

The Department's program is concentrating at present on high-risk, high-payoff research and development, with less emphasis on short-term research and development. The utility sector already has on order (to be built by 1985) more geothermal powerplants than it had projected as recently as 1979, and the Department is phasing out its activities in hydrothermal industrialization. The goal now is to develop those elements of advanced geothermal technologies that the private sector is currently unable or unwilling to undertake, but which will be required for full commercial development of the Nation's extensive geothermal resources. It also is important to transfer these research and development results to the geothermal industry. The major objectives and needs to be met are listed in Table 30-2.

The Geothermal Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-410) established the Geothermal Energy Coordination and Management Project (now called the Interagency Geothermal Coordinating Council) and directed the project to develop a coordinated Federal program and report to Congress. The program directed by Congress included demonstration plants, loan guarantees, and extensive lists of necessary research and development activities to be undertaken. The wide range of functions and activities named in the Geothermal Energy Research, Development, and Demonstration Act were amended or expanded in the Energy Reorganization Act of 1974 (P.L. 93-438), the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), sections 102 and 203 of the Department of Energy Organization Act of 1977 (P.L. 95-91), sections 101, 501-512 of the Department of Defense appropriations bill for fiscal year 1974 (P.L. 93-238), and Title VI of the Energy Security Act of 1980 (P.L. 96-294).

The Interagency Geothermal Coordinating Council (IGCC), chaired by the Assistant Secretary for Conservation and Renewable Energy in the Department of Energy, has monitored and coordinated the program activities of eight Federal agencies having responsibilities for various aspects of geothermal development. The IGCC has succeeded in identifying alternative policy options, streamlining administrative procedures, and avoiding potential duplication among research and development efforts in the Federal geothermal program. The Council also developed midterm targets and long-term estimates of geothermal utilization. It projected about half the geothermal energy in the year 2000 as coming from geopressured methane (which is actually a form of unconventional fuel-gas production, rather than geothermal energy), and it projected that most of the growth in hydrothermal utilization would come after 1990.

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*Geothermal fluids are considered to be of "moderate temperature" if they are between 150° and 180° C (about 300° to 360° F). Anything above 180° C is considered "high temperature."

Program Results

The Department of Energy's research and development activities have significantly reduced the risk involved in finding suitable geothermal resources across the country, while also reducing the cost and uncertainty involved in trying to use them. In doing so, the program has significantly increased the size of the economically exploitable geothermal resource base and stimulated the nonelectric geothermal industry, which is now expanding rapidly.

The program assisted in identifying geothermal resources in 32 states, bringing the number of states with promising hydrothermal reservoirs (steam or hot water trapped in relatively near-surface rocks) to 37. These include high- and moderate-temperature resources in the Western United States and new areas of promise for low- to moderate-temperature hydrothermal resources in the Eastern United States.

The reservoirs whose existence has been confirmed are sufficient to allow private industry to meet the IGCC goal of 3,000 megawatts-electric of electric capacity by 1985; and recent orders indicate that this target will be reached on schedule. Through program activities, electricity is now being generated in the Imperial Valley in California. The economic production of power from hot water reservoirs also is expected in several western states in the near future.

Successful Department tests of improved drill bits, downhole motors, improved drilling fluids, and well-completion equipment and techniques have given confidence that improved technology will be available by 1983 to meet the objective of a 25-percent reduction in drilling costs. Energy conversion research and development has been directed toward cutting generating costs--particularly for moderate-temperature resources, which are more prevalent but more expensive to develop than those of high temperature. Successful testing of three small-scale binary-cycle power systems (employing direct-contact heat exchangers) suggests that capital costs for electric generating facilities might be lowered 20 percent by 1987. Recent improvements to technology through research and development have cut the potential cost of geothermal electric power and thus nearly doubled the amount of the resource that is economically competitive. It is estimated that research and development efforts through fiscal year 1981 have reduced average electric busbar costs 7 percent for high-temperature resources (from a base of 20 mills per kilowatt-hour) and 10 percent for moderate-temperature resources (from a base of 120 mills per kilowatt-hour).

A great deal has been learned about using hydrothermal resources for electric power production through the construction and operation of a 5 megawatts-electric pilot plant in Raft River, Idaho, and a 3 megawatts-electric geothermal wellhead generator system in Hawaii, as well as through the design of a commercial-scale flash-steam demonstration plant of 50 megawatts-electric at Baca Ranch, New Mexico. Utility companies have now announced publicly their intentions to build new hydrothermal electric generating plants using hot water reservoirs (as distinguished from steam fields) to produce additional generating capacity totaling more than 1,000 megawatts-electric.

The technology for using hydrothermal energy directly for space heating and process heat is well developed and economical. Private industrial activity has been stimulated by the program's funding of 50 technical and economic studies of direct-heat applications designed to match the energy needs of prospective users with specific low- to moderate-temperature resources, and the initiation of 23 DOE cost-shared demonstration projects to show that various applications of geothermal energy to direct heat can be profitable. More than 100 viable geothermal projects for direct-heat use were also aided during the past 2 years through Department of Energy support of state development planning projects. The combined efforts of DOE and the private sector resulted in 240 direct-use developments in 16 different states, providing 18,230 billion Btu's annually (0.019 quad) at the end of 1981.

To facilitate the flow of private capital into the higher risk areas of the geothermal industry, the geothermal loan guarantee program was established. Five loan guarantees, totaling $136 million for projects costing $202.7 million were awarded. Four of these projects will provide an added 258 megawatts-electric to current electric power production, and the other project is providing 117 billion Btu's per year (0.0002 quad) for food processing.

Uncertainties about the size, characteristics, and potential use of the very large geopressured and hot dry rock resources also have been greatly reduced by efforts within the Department's program; but the technical and economic feasibility of extracting energy from these sources has not been proven yet.

Known geopressured resources under study are the hot water aquifers, containing dissolved methane trapped under high pressure in deep sedimentary formations, located along the Gulf Coast. The initial program effort defined geopressured aquifers in Texas and geopressured drilling sites in Louisiana. To date, short-term testing of resource characteristics has been completed for 16 existing oil and gas wells; and long-term testing of reservoir characteristics is under way for 4 specially designed production wells. By the end of 1982, geologic studies and well testing will have produced detailed reservoir data. The results of these production tests and critical research and development projects will provide the first insight into whether or not it will be technically feasible to develop geopressured resources.

As noted above, hot dry rock resources are geologic formations at accessible depths that have abnormally high heat content but contain little or no water. Useable energy is extracted by circulating a heat-transfer fluid, such as water, through deep wells connected by manmade fractures in the rocks. Early in fiscal year 1978, a 5 megawatts-thermal loop created by hydraulic fracturing in deep wells was operated on an experimental basis at the Fenton Hill hot dry rock resource site in New Mexico. The second phase of the project began in fiscal year 1980, with completion of the first well of a large (20 to 50 megawatts-thermal) thermal loop to pass through the hot dry rock; the second well was completed in fiscal year 1981. Development of the actual underground heat transfer system will start in mid-1982 (fiscal year), with a series of fracturing experiments to be followed by surface system construction. Because this system will be near-commercial in its design, it should provide some critically needed data on reservoir lifetime and operating characteristics.

Program accomplishments and corresponding budget data for fiscal years 1978 through 1981 are summarized in Table 30-1.

Geothermal technology has proven to be relatively safe, and its broader use is not known to present any insurmountable health problems. The Department of Energy's program has included research and development in environmental control technology, along with field activities designed to monitor and mitigate possible adverse impacts of program activities associated with the development of hydrothermal, geopressured, and hot dry rock resources. A number of potential environmental problems have been associated with geothermal electric generation: release of airborne effluents, particularly hydrogen sulfide; disposal of large volumes of spent geothermal fluids, with varying amounts of dissolved solids; high noise during drilling and field operation; possible subsidence of the surface as large volumes of fluid are withdrawn; the possibility that seismic activity could be induced by fluid withdrawal or reinjection; requirements for cooling water; and simple conflicts over land use. Airborne emissions and possible water use are believed to be the principal problem areas, and none of the other potential environmental impacts are expected to impede resource development seriously. Technology that is now in its final development stages on a commercial scale appears capable of meeting air quality standards for H_2S, but water use conflicts will have to be addressed on a site-by-site basis. In general, the environmental impacts of nonelectric uses are more benign, because the fluids most likely to be used for district heating or process heat are lower in temperature and tend to contain fewer dissolved solids.

Projected Program Requirements

Congress has appropriated $55.4 million for the geothermal program in fiscal year 1982. This level of funding will provide for hydrothermal resource development, permit evaluation of economically recoverable geopressured resources, and improve the understanding of the technical and economic feasibility of exploiting the potentially very large hot dry rock resources. This reduction in funding from previous years will place greater reliance on the private sector to develop and exploit geothermal resources at a pace determined entirely by the marketplace.

A 10-percent increase in the contemplated level of support would accelerate the development of advanced binary-cycle power technology, permitting demonstration of the economic viability of moderate-temperature hydrothermal generating systems by 1986 instead of 1987. If funding levels were decreased by 10 percent, there would be a delay of 1 year in the projected decision points for technical assessment of whether or not geopressured and hot dry rock resources can be developed economically.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

2. Conservation and Energy Systems

OVERVIEW

The shock of the Arab oil embargo of 1973-74 stimulated significant interest at the Federal level in energy conservation. The two energy agencies that were created in 1974--the Federal Energy Administration (FEA) and the Energy Research and Development Administration (ERDA)--incorporated functions that addressed conservation directly. At FEA, an Office of Energy Conservation concentrated on encouraging public acceptance of conservation through information activities, economic incentives, and regulatory activities, including emergency energy demand curtailment measures. An office with the same name at ERDA tried to pursue research, development, and demonstration of technologies that could improve the efficiency of energy use. One basic purpose in establishing the Department of Energy in 1977 was to consolidate Federal energy activities within a single organization. In the case of conservation, the short-term and long-term responsibilities were united at that time.

The initial FEA and ERDA legislative charters concerning energy conservation were not very specific. These charters, however, were soon augmented by a steady succession of more precise legislative guidance:

- The Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) authorized energy conservation research, development, and demonstration activities

- The Energy Policy and Conservation Act of 1975 (P.L. 94-163) authorized the establishment of state energy conservation programs and industrial energy conservation programs

- The Energy Conservation and Production Act of 1976 (P.L. 94-385) authorized the development of energy efficiency standards for buildings as well as weatherization assistance for low-income persons

- The National Energy Conservation Policy Act of 1978 (P.L. 95-619) established the Residential Conservation Service to be implemented by states and utilities, required consideration of energy efficiency standards for certain consumer products on a statutory schedule, and authorized energy conservation programs for schools, hospitals, and buildings owned by units of local government and public care institutions

- The Energy Security Act of 1980 (P.L. 96-294) authorized financial assistance to encourage the commercialization of energy from municipal waste and expanded the Residential Conservation Service to include small commercial buildings and multifamily dwellings

Although these programmatic legislative instructions for energy conservation were diverse in content and method, they shared a common overall aim: to encourage greater efficiency in the end-use of energy. The national conservation program strategy that evolved was primarily one of trying to offset the disincentives to conservation which resulted from energy prices being kept artificially low through price regulations. Various other barriers that impeded development and use of cost-effective energy technologies also were addressed. The Federal programs can be generally characterized by one or more of the following strategies:

- Disseminating information about the economic and technical feasibility of various energy conservation techniques to encourage businesses and other energy consumers to make more informed decisions about implementing such techniques

- Supporting research and development, perceived as unlikely to be pursued by the private sector, to increase and broaden the options available for increasing efficiency in the end-use of energy and substituting readily available energy sources for scarcer ones

- Providing financial incentives to make conservation technologies more attractive and to accelerate their adoption by the marketplace

- Implementing standards and regulations where the marketplace was believed to have failed to respond to other measures in a timely manner and where the potential benefits to the Nation were felt to be large

- Reducing some institutional and regulatory barriers to conservation--for example, the encouragement given to cogeneration through the implementation of the Public Utility Regulatory Policies Act of 1978 (P.L. 95-617)

Largely because of rising energy prices, the U.S. economy has become considerably more energy efficient since 1973, especially since 1979 with the additional impetus provided by oil price deregulation. Despite an increase in population and a rising gross national product (GNP), total annual energy consumption increased from about 76 quads in 1973 to barely 78 quads in 1980 (down from a peak of around 80 quads in 1978 and 1979).*

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*These statistics, like others in this report, include the use of biomass--predominantly wood. Thus, they vary slightly from figures released earlier by the Energy Information Administration.

Perhaps of equal importance is that the major reduction in energy consumption has been in imported oil, because this is the specific component of our national fuel mix that makes us most vulnerable to future supply disruptions. Oil imports fell from more than 8 million barrels per day in the late 1970's to less than 6 million barrels per day in 1981.

The dramatic increases in energy prices since 1973 have had a profound effect on the U.S. economy. Today consumers pay, directly or indirectly, $400 billion per year for energy--15 percent of GNP, compared to less than 5 percent of GNP in 1971. One consequence of higher energy prices is reduced energy use per dollar of GNP. This ratio has declined by 13 percent since 1973. As energy prices increase relative to other resources, a natural and expected market response is to use less energy and, if possible, to substitute other goods and services.

Although energy consumption per dollar of GNP has risen and fallen at various times since World War II, the steady downward trend since 1973 is a marked departure from historical behavior. The 1980 estimate of 51,400 Btu's per constant (1972) dollar of GNP is substantially below that of any other time in the last 30 years. This reduction roughly translates into about 12 quads of foregone energy use, compared with 1973 efficiency levels, or a savings of about $60 billion in 1980 energy purchases.

The conservation programs of the Department of Energy have played some role in this national trend, although the exact effect is difficult to quantify. Reviews of DOE conservation programs through fiscal year 1981 indicate that these programs have been responsible for significant savings in absolute terms, even though a major emphasis of these programs was on longer term research and development. In relative terms, however, the effects to date of the Department's conservation programs as well as of tax credits on national energy consumption are believed to be small, probably accounting for less than 5 percent of the observed reduction in energy use per unit of GNP.

DOE's conservation program funding has supported a wide range of activities. For example, approximately one-third of the Department of Energy's conservation budget in fiscal year 1981 focused on research, development, and demonstrations. About one-half of the budget was allocated to financial incentives or assistance, such as grants to state and local governments in preparing for energy emergencies, the development of state energy conservation plans, energy audits for schools and hospitals, weatherization for low-income people, or energy impact aid. Most of the remainder was used to fund education or information activities, with approximately 3 percent relating to congressionally mandated standards and regulations. Some of these programs were expected to have rapid effects, but most were expected to produce a more gradual influence over time. The successful projects in the research and development programs, which accounted for much of the budgetary outlays, are yet far from reaching their full effect.

The seven program analysis units that follow provide more detail about past and current Federal conservation programs. These are Buildings and Community Systems (including research and development on energy use in buildings, technology for using municipal waste as an energy source, and the Federal Energy Management Program); Industrial Conservation; Transportation

Conservation; Multi-Sector Conservation (including Energy Conversion and Utilization Technologies, Energy-Related Inventions, and Appropriate Technology); State and Local Programs; Electric Energy Systems; and Energy Storage Systems.

Energy conservation is a clearly desirable long-term policy whose realization will be facilitated by well-informed market decisions and correct energy pricing. The Reagan Administration believes that as energy prices rise, there is less need for Federal conservation programs designed to reduce the wasteful use of energy that was encouraged by the artificially low energy prices of the past.

Although the Department's overall goal of increasing energy efficiency is unchanged, many programmatic goals and objectives relating to conservation have been refocused under the Reagan Administration to stress long-term generic research and selected efforts in transferring technology to the marketplace. Funding reductions have been made to conform with current budgetary policies in this period of fiscal restraint.

Based on an assessment of DOE's conservation programs in light of the effect that market forces appear to be having on conservation in all sectors of the economy, a new ordering of priorities is justified. The Administration believes that industry itself should be responsible for developing more efficient processes, equipment, and products; and that such development will occur rapidly and efficiently only if energy prices reflect true costs. The Federal Government, however, will continue long-term, basic conservation research efforts unlikely to be undertaken by the private sector.

In light of the substantial efforts to use energy more efficiently among all segments of society, Federal funding of the energy conservation planning, information, and investment activities is no longer generally necessary. The Administration will continue to provide substantial assistance to the truly needy through the Low Income Home Energy Assistance Program of the Department of Health and Human Services and through the Community Development Block Grant Program at the Department of Housing and Urban Development.

(31) BUILDINGS AND COMMUNITY SYSTEMS (CE)

Department of Energy activities relating to Buildings and Community Systems (BCS) have included programs conducted by two separate offices: the Office of Building Energy Research and Development, which deals with residential and commercial buildings (where more than 35 percent of total U.S. energy was consumed in 1980); and the Office of Urban Waste (recently renamed the Energy from Municipal Waste Division), which was created by the Energy Security Act of 1980 (P.L. 96-294) and which was chartered to accelerate the use of municipal waste as an energy source. When the Department of Energy was formed, the activities of both these offices were under BCS. They were subsequently separated, and therefore, they will be discussed separately in this program analysis unit.

BUILDING ENERGY RESEARCH AND DEVELOPMENT

Program Objectives

When the predecessor to Building Energy Research and Development (BERD) was formed in the early 1970's, the program objective was to mount an aggressive energy conservation effort in the building sector.

The focus of BERD activities was on new building-design practices and new products that could be introduced rapidly into the marketplace. Because the problem was perceived to be severe and because getting the building industry to respond was expected to be very difficult, the use of regulations was seen as appropriate. BERD was directed to develop appliance efficiency standards and to devise rules directing utilities to offer energy audits and retrofit services to their residential customers. Innovative ways were also sought to market and commercialize energy-efficient products and technologies. Communities were shown how to initiate energy-conscious planning and management and how to build efficient systems, such as district heating.

Over time, the office also was given various related assignments. The development of the Building Energy Performance Standards was transferred from the Department of Housing and Urban Development (HUD). After the 1979 Iranian oil crisis, BERD developed and implemented the Emergency Building Temperature Restrictions Program. BERD also was given responsibility for the Federal Energy Management Program (FEMP), the Federal Government's own energy conservation and renewable energy program. Finally, BERD directed the Department's role in the Energy Impact Assistance Program, a grant program to communities affected adversely by new coal and uranium mining activities.

The basic objectives of BERD were to reduce energy consumption in existing buildings by 20 percent between 1978 and 1985 and to cut the energy used in new buildings by 30 percent during the same period. Between 1978 and 1985, FEMP aimed at a 20-percent reduction in energy use by existing Federal buildings and a 45-percent reduction for new Federal buildings. The equipment research program's objective was to introduce household appliances that used 30 percent less energy, space-heating equipment that used 50 percent less energy, and lighting systems that used 50 percent less energy than the average efficiencies of 1978 products. The community research program sought to demonstrate new planning techniques and systems that would use 40 percent less energy than conventional approaches.

The strategy for reaching these objectives was to determine the energy used in the building sector by different functions (for example, heating, cooling, and lighting); to inventory the research that could increase efficiency in each of these functional areas and in the system as a whole; to identify the most promising technologies; and then to devise efforts (consistent with congressional mandates) that would accelerate the commercial introduction and market acceptance of new, more energy-efficient practices and products. As the commercial value of such practices and products became evident, the industries involved assumed a larger share of the cost.

These active, varied BERD programs were mandated by an outpouring of energy legislation beginning in 1973. The Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) directed the Energy Research and Development Administration (ERDA) to initiate a national energy conservation research, development, and demonstration program. The Energy Policy and Conservation Act of 1975 (P.L. 94-163) directed the newly created Federal Energy Administration (FEA) to develop test procedures and energy efficiency targets for major home appliances; and the legislation also established an energy conservation program for Federal buildings and operations. The Energy Conservation and Production Act of 1976 (P.L. 94-385) directed HUD to develop and promulgate building performance standards for new residential and commercial buildings and mobile homes. The Department of Energy Organization Act of 1977 (P.L. 95-91) transferred these responsibilities to DOE. The National Energy Conservation Policy Act of 1978 (P.L. 95-619) established the Residential Conservation Service Program, called for life-cycle cost procedures for Federal conservation investments in Federal buildings, and required consideration of minimum efficiency standards for 13 types of major home appliances. The Powerplant and Industrial Fuel Use Act of 1978 (P.L. 95-620) provided grants for areas "impacted" by coal and uranium mining. The Energy Security Act of 1980 expanded RCS to include multifamily apartments and small commercial buildings, authorized auditor-training grants to states, and authorized the Residential Energy Efficiency Program, a building retrofit demonstration program.

Such a broad, aggressive Federal role in encouraging conservation is no longer necessary. The use of energy depends upon millions of individual and corporate decisions. Rising energy prices and the deregulation of petroleum prices are the most effective ways of ensuring that these millions of decision-makers avoid wasting energy. Manufacturers will respond to consumer pressures for more efficient products by developing new products.

Accordingly, BERD's research objective for fiscal year 1982 has been redirected toward long-term, generic, high-risk technologies that offer large potential savings, but are not yet attractive to the private sector. It is anticipated that these activities will be folded into the Energy Conversion and Utilization Technologies Program in fiscal year 1983.

Program Results

BERD made substantial progress in fiscal years 1978 to 1981 toward meeting the objectives set for it by Congress and the Department. The discussion below highlights this progress. Details are presented in Table 31-1.

Research, Development, and Demonstration. The energy requirements of a building involve intimate interactions among the building systems; the heating, cooling, lighting, and other equipment; and the community system. In the past, gross inefficiencies in each of these elements and in the way they interacted had drawn little attention because energy costs were so low.

In the building systems area, BERD performed basic research on the building envelope (walls, roofs, and windows), as well as on materials, ventilation, and controls. It used performance calculations and diagnostics, and pilot projects and case studies.

Research was performed for the first time on three-dimensional wall sections under static and dynamic conditions. The deterioration of wall components became better understood, as did the heat transfer between buildings and the surrounding earth, and the storage of heat within materials. The study of windows, shutters, and shades showed that actual performance was even lower than the values published in standard literature. Therefore, BERD worked with manufacturers to develop prototype window systems that are 65 to 85 percent more energy efficient than existing ones. The energy-saving potential of "daylighting" in office buildings was identified. Basic research on insulating materials revealed heat transfer, moisture, corrosion, degradation, and flammability effects that have led to changes by manufacturers and building designers.

To measure air infiltration into and out of residences, BERD developed blower-door and tracer-gas equipment for field tests. For the first time, a scientific examination was made of code requirements for air exchange rates; and the results showed that the required rates often are excessive and wasteful. The concept of "house-doctoring" for comprehensive energy savings in homes was developed and tested; and it has been adopted by private conservation service companies. The DOE-2 computer model was developed to estimate the energy use of a building from its design. Originally a research tool, DOE-2 has been adapted in simplified form for use by designers, builders, and homeowners with a handheld calculator or microcomputer.

In the building equipment area, DOE-assisted research has concentrated on space-heating equipment, appliances, and lighting. In space heating, a highly efficient wood-fired boiler and a nonsooting oil-fired boiler were developed and introduced for residential use. Both products used advanced combustion processes. A power gas burner and a furnace efficiency meter were also introduced into the marketplace by the private sector. By mid-1982, two oil burners using advanced atomization processes developed under the DOE research and development program are scheduled for market introduction. These will allow the marketing of variable low firing-rate furnaces and boilers that will increase system efficiency by 15 to 20 percent over conventional designs.

In the appliance area, BERD cost-shared the development of the first successful heat-pump water heater (thereby creating a new industry) and an advanced refrigerator-freezer. Each cuts energy use in half. An advanced motor compressor for refrigerators, developed under a DOE contract, will be introduced in mid-1982 by a leading appliance compressor manufacturer. This product will offer a 35-percent improvement in compressor operation for a cost of less than $20 per unit.

BERD also has made progress in research on high-risk technology. A Stirling engine freon compressor for gas-fired heat pumps was tested successfully for the first time, and the first U.S. field test of an absorption heat pump using organic fluids was conducted. The first materials durability data applying specifically to oil-fired condensing heating systems was also produced.

At the community level, energy consumption depends upon the overall design of the community, the way it functions, and the overall efficiency of its energy delivery systems. Innovative delivery systems, such as district heating, can produce savings, as can land-use plans that cluster housing along mass transit spines. BERD research has identified and demonstrated some of the most promising of these options and the results have been passed along to local decision-makers.

District heating systems distribute hot water or steam effluent from powerplants (and other sources) through a piping network to provide heating, cooling, and process energy. The combination of electricity generation and heat use is called "cogeneration." The idea of district heating (as opposed to using the rejected heat directly on site) is not new, although the technology of transmitting hot water (rather than steam) has been perfected in Europe only in the last 30 years and has not penetrated the U.S. market. Cogeneration systems permit the use of up to 80 percent of the energy released from the fuel consumed, as compared with less than 40 percent obtained from conventional generating plants. In some cases, such systems enable coal to replace the oil that might have been used in individual heating units. The construction of such systems creates urban jobs, and their installation may partially insulate urban areas from future energy price increases. In 1977, BERD awarded feasibility grants to seven cities, six of which have projects that now are moving into or nearing construction. The program also developed analytical tools that public and private officials can use to determine the feasibility of district heating systems; these are being used in 28 community studies under grants from DOE and HUD.

In a similar program, BERD provided planning grants for Integrated Community Energy Systems (ICES); and five demonstration projects are now being built. The University of Minnesota ICES is intended to show how a university powerplant can provide space heating for itself and nearby hospitals, while generating electricity for itself and delivering some through an interconnection to a privately owned utility. The Trenton Project will serve a number of diverse buildings in an urban center from a central cogeneration facility, to be built and operated by a special corporation established in the city for that purpose. The ultimate potential energy saving by these five projects could be as much as 5 million to 10 million barrels of oil equivalent (0.03 to 0.06 quad) per year.

As an aid to community leaders and planners, BERD provided grants to 25 cities under the Comprehensive Community Energy Management Program (CCEMP). The funds were used by these communities to analyze how energy was being used, how energy efficiency might be achieved, and what economic, institutional, and technological barriers to higher energy efficiency existed. The communities developed energy management plans and programs; and their experience is being documented in a guidebook for use in other localities.

In a related program, Site and Neighborhood Design, developers received grants to design a subdivision using conventional practices and then to redesign--with help from BERD--for energy efficiency. The redesigns clustered housing, minimized transportation requirements, used natural topography and woodlands, and incorporated community energy systems. The result was a 20- to 65-percent decrease in projected energy requirements. The redesigns were not more expensive, but they took more time and often required changes in local zoning ordinances. These lessons also are being passed along to other cities.

The community programs also initiated Operation Powerplay, in which a group of the major commercial, industry, or government customers of a utility join together in a cooperative peak-load management program. They agree to reduce their demand when the utility has high system-wide demand in return for lower electricity rates. Five such cooperatives are now in operation, and 10 more are in the planning stage.

Regulatory Programs. The buildings area is highly visible and involves millions of decision-makers. Because energy prices did not reflect the true value of energy resources, Congress mandated certain regulatory programs to achieve energy savings. BERD has managed several of these, including the Building Energy Performance Standards, Appliance Standards, Residential Conservation Service, Emergency Building Temperature Restrictions, and the Federal Energy Management Program.

The Building Energy Performance Standards Program, first assigned to HUD and then transferred to DOE, called for the development of nationwide energy-efficiency design standards for new residential and commercial buildings. BERD developed an advance notice and proposed rules, but believes that mandatory Federal regulations on building efficiency would be too burdensome and are not needed. The effort, however, has spurred research that is widely applicable with or without regulations.

Appliance Standards were one regulatory element in a program that also included development of test procedures, support for the Federal Trade Commission (FTC) in the appliance labeling program, and a consumer education activity. The test procedures were developed in cooperation with the

National Bureau of Standards. By statute, manufacturers are required to use the results of these tests in any energy-efficiency claims and in FTC's labeling program. Consumers are thus ensured reliable information when making purchase decisions. The standards portion of the program considers the need for mandatory nationwide efficiency requirements for 13 product categories. The Administration decided in early 1981 that additional analysis was needed in this area and that results should be published early in 1982.

The Residential Conservation Service Program (RCS), enacted by Congress in 1978, requires major electric and gas utilities to offer home energy audits and certain other services to their residential customers. By late 1981, 47 states had developed plans for implementing RCS programs and many states and utilities already were providing the conservation services. To assist states and utilities, BERD developed a model audit, conducted auditor training programs, produced guidebooks on how to implement the program, and published product safety and effectiveness standard conservation measures, which have been adopted by private standards organizations and the U.S. Navy.

BERD also was given responsibility for administering the Emergency Building Temperature Restrictions Program, initiated in 1979 in response to the Iranian oil embargo. Regulations were completed and sent to some 3 million building owners and managers within 6 months. The program was discontinued by President Reagan in February 1981, after the supply crisis had subsided.

The Federal Energy Management Program has responsibility for the Federal Government's own energy conservation and renewable energy programs. The Federal Government is the Nation's largest energy user, with a 1980 energy bill of $8.9 billion. The FEMP Program involves developing guidelines for long-term building and operation planning, reviewing and approving the plans of Federal departments, developing a life-cycle costing methodology to be used in making Federal conservation investments, providing information and assistance, monitoring Federal performance, and making regular reports to Congress and the President. The Federal Government has reduced its energy use in buildings and facilities from 161 million barrels of oil equivalent in fiscal year 1975 to 146 million barrels of oil equivalent in fiscal year 1980--a 9.3 percent reduction. Cumulative savings during this period amounted to 49.4 million barrels of oil equivalent (0.29 quad), at a cost avoidance of $980 million in 1980 dollars.

Information and Education. The objective of achieving immediate savings--as well as long-term benefits--led to implementation of a number of information and education programs. These programs are no longer considered necessary given the widespread availability of such information from other sources.

These support programs are typified by a training program for [illegible]00 members of architectural faculties. At least one faculty member from [illegible]2 of the 98 accredited U.S. schools of architecture has attended these seminars on energy-efficient design practices, which are held annually at the Massachusetts Institute of Technology. Thousands of students have benefited.

The Low-Cost/No-Cost project demonstrated the benefits of a concentrated marketing program by providing simple, attractive energy conservation packets to 6 million homeowners in the New England states. The program, accompanied by radio and television advertising and endorsements from public and private leaders, also provided free shower-flow controllers. The packets showed homeowners the actions individuals could take to save 25 percent of their energy costs with an investment of $100 or less. An evaluation of the program showed that the energy savings resulting from the actions of participating homeowners totaled 1.75 million barrels of oil equivalent (0.01 quad) in the first year.

The Fuel Oil Marketing Program was a similar marketing experiment, but one targeted to homeowners and renters with oil furnaces--primarily in the Northeast. Local oil jobbers, trained in furnace efficiency analysis, offered furnace retrofit services to homeowners. BERD cooperated with state energy offices and state fuel oil marketing associations on the project, providing training manuals and low-cost retrofit guidelines.

The Small Business Program identified practical and technical measures that could be taken to save energy for 16 types of businesses involving large numbers of small firms, such as apartment management, retailing, laundry, and dry cleaning. Energy-saving guidebooks were prepared for these businesses, and more than one million have been distributed through their trade associations.

Financial Incentives. The BERD objectives also have been pursued through programs that provide financial incentives for energy conservation such as tax credit programs and Energy Impact Assistance.

The Crude Oil Windfall Profit Tax Act of 1980 (P.L. 96-223) authorized an extension of tax credits to additional products that save energy and would benefit from such credits. The Department of the Treasury is required to consult the Department of Energy in making such additions, and BERD performs the engineering and economic analysis of candidate products. Some 125 applications are expected to be reviewed in fiscal year 1982.

The Energy Impact Assistance Program provides grants to communities that are experiencing rapid growth because of coal and uranium developments. To date, 95 areas covering 284 counties have been approved for assistance. Grants numbering 466 and totaling $57 million have been made. They include 160 planning grants and 306 grants for acquisition and development of sites for schools and other facilities. The Department's role in the program was housed in BERD because of its community energy planning experience.

Projected Program Requirements

Congress has appropriated $42.9 million for fiscal year 1982 for BERD. No funds will be requested for this program in fiscal year 1983 although generic research applicable to energy conservation will be conducted in the Energy Conversion and Utilization Technologies Program.

The fiscal year 1982 funds will be used for basic research on thermal heat transfer and other generic research topics that can support private sector development activities in such areas as building envelope systems, ventilation controls, performance calculations, test procedures for appliances, advanced conversion equipment, and district heating technologies. In addition, funds will be available to complete the 10-year Federal building plan, a Federal emergency contingency plan, and related FEMP activities. Fiscal year 1982 funds also will be used to provide for an orderly termination of research and development efforts. The FEMP activities will be further decentralized to other departments, with the BERD role being terminated.

A 10-percent increase or decrease in funding would have little dollar or program impact. Program activities would not change, but the timing would be slightly advanced or slowed.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

OFFICE OF URBAN WASTE

Program Objectives

The goal of the Urban Waste Program was to increase the use of municipal waste as a source of energy and materials and to improve the efficiency of water and wastewater processing technologies, to produce or conserve the energy equivalent of 25,000 barrels of oil per day (about 0.05 quad annually) by 1985. To do this, the Office of Urban Waste (currently, the Energy from Municipal Waste Division) sought to resolve the technical, economic, institutional, and environmental problems that impeded greater participation by the private sector.

This program was developed in stages in response to several legislative mandates. The Federal Nonnuclear Energy Research and Development Act authorized Federal efforts to advance energy conservation technologies that include the use of garbage and sewage to replace conventional fuels, and the reuse and recycling of materials and consumer products to avoid the higher energy requirements of original production. The Department of Energy Act of 1978--Civilian Applications (P.L. 95-238) ensured adequate Federal support to demonstrate municipal waste processing for the production of fuel and the recycling of energy-intensive products. It also authorized the gathering and dissemination of information about the technological, economic, environmental, and social costs and benefits of demonstration facilities. The Alternative Fuels Production Act of 1980 (P.L. 96-126) appropriated money for the Department to support feasibility studies of alternative fuels. The Energy Security Act authorized the Department to conduct research, development, demonstration, and commercialization activities relating to the recovery of energy from municipal waste, and directed the Department to develop an analysis of barriers to broader development and application of the associated technologies.

Table 31-1 details the activities of the Urban Waste Program including research, development, demonstration, and the dissemination of technical and economic cost information, as well as provision of some financial assistance for studies in the form of cost-shared grants and loans. The most recent strategy of the program has been to concentrate on the long-term generic research and development that has not been addressed by the small and fragmented waste-to-energy and wastewater treatment industries and is not handled by the Environmental Protection Agency.

Program Results

The degree to which the original objectives of the Urban Waste Program have been met is documented in Table 31-1. During fiscal years 1978 to 1981, 42 distinct waste-to-energy technologies (24 biological, 12 thermal, and 6 mechanical) were investigated to find ways of improving economic, technical, and environmental performance. Of the 25 feasibility studies initiated in fiscal year 1978, 20 resulted in projects that are proceeding to construction. Through an investment of just over $7 million, more than $1 billion in private capital has been attracted to those projects--which are expected to provide 15,000 barrels of oil equivalent per day (about 0.03 quad per year), or 60 percent of the 1985 program goal.

The 16 projects being monitored by the Urban Waste Program under the Alternative Fuels Production Act are expected to provide an additional 8,500 barrels of oil equivalent (about 0.017 quad per year) when carried to completion--so that the full goal is now in sight. In addition, 66 technical reports have been distributed to more than 150 municipalities, 56 research institutions, 29 trade associations, 400 engineering consulting firms, and 51 interest groups, as well as to the general public. Thus, it is reasonable to assume that the technical advances embodied in these projects will be used as models for others.

Local governments and industry both have benefited from the Urban Waste Program. Localities have received additional income from the sale of recovered materials, the employment generated by these labor-intensive facilities, and a reduction in landfill pollution. The industrial firms that have carried out the actual design and construction of the urban waste facilities have derived important technical information and know-how.

The program has helped make a number of waste-to-energy technologies commercially available. The success of the program in demonstrating commercial systems and in developing some alternatives to the proof-of-concept phase obviates the need for any further Federal support. Implementation decisions should be made in competition with the alternative use of capital without direct Federal involvement. Any further development of waste-to-energy technologies must be put to risk/investment tests that are best applied to the private sector.

The most notable environmental benefits of the technologies supported by the Urban Waste Program are the reduction of air pollutants and the mitigation of ground and surface water pollution through reduction in the need for landfilling.

Projected Program Requirements

Congress has appropriated $4.8 million for this program in fiscal year 1982. These funds will be used to phase down activities in urban waste in the biological, thermal, mechanical, and systems/interrelation areas and to complete the report to Congress that identifies institutional barriers.

No funds will be requested for the program in fiscal year 1983 in recognition of the commercial availability of certain waste-to-energy technologies and the belief that further developments in the technologies will be supported by the private sector as they become cost effective. Basic and generic research in support of this activity can continue in other programs.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(32) INDUSTRIAL CONSERVATION (CE)

The industrial sector consumes nearly 40 percent of all energy used in the United States, deriving more than half of its share from oil and natural gas. During the past 10 years, U.S. industry has reduced the amount of energy it consumes per unit of output by an average of more than 1 percent annually; yet energy end-use efficiency remains relatively low in many industrial applications. Part of the decrease in energy use per real dollar of gross national product (GNP) can be traced to a general economic shift from heavy production and manufacturing toward "white collar" service industries, which are inherently less energy-intensive. The fact remains that much of the huge U.S. industrial complex (consisting of 460,000 manufacturing, mining, construction, and agricultural firms with capital equipment valued at more than $750 billion) was established during several decades of abundant and low-cost energy. There is still considerable room for improvement in industrial energy efficiency.

Industry has achieved, and should continue to achieve, significant energy savings on its own. This trend has been reinforced by moves toward more realistic energy prices, which make energy conservation efforts an important component of business management. Even some long-term energy conservation technologies eventually will be pursued by the private sector when they are economically justified. Historically, private enterprise has been reluctant to pursue long-term energy conservation technologies entirely on its own for a variety of reasons, including high technical and financial risks, uncertainty about the return on investment, and the inability of small and rather highly fragmented industries to mount their own research and development programs. In many cases, the ratio of energy cost to product cost is low, and it is not always easy to correlate product pricing with "embodied" energy costs. There may simply be a dearth of practical energy-saving technology and technical expertise; and an individual firm that chose to develop them through privately funded research might not be able to obtain and hold economically meaningful patent benefits. Many companies have been quick to adopt proven technology and techniques for saving energy, but have found higher priorities for long-term investment than for some potentially significant research and development in the field.

Program Objectives

Based in part on these perceptions, the initial goal of DOE's Industrial Conservation Program as mandated by Congress was to cost-share research, development, and demonstrations and to inform the private sector about the costs and benefits of energy conservation technologies. These were to be developed to make more technology available commercially to industry and agriculture for improving the energy efficiency of processes, for reducing energy waste, and for substituting more abundant fuels for scarce ones. The long-term objective was to encourage industry to achieve incremental annual energy savings of 5.5 quads by the year 2000 from industrial investment in the technologies supported by DOE. The shorter range goal of saving 1.5 quads by 1985 was cut back to 1.0 quad 2 years ago. The current goal is to terminate the program at the end of fiscal year 1982, recognizing that deregulation of domestic energy prices gives U.S. industry ample incentive to address all cost-effective energy conservation needs on its own.

This program was developed in response to a variety of enabling statutes, which mandated various elements as follows:

LEGISLATION	SPECIFIC LANGUAGE
P.L. 93-577, Federal Nonnuclear Energy Research and Development Act of 1974, Section 4, Paragraph b, Section 4, Paragraph c	". . . Formulate and carry out a comprehensive Federal nonnuclear energy research, development and demonstration program." ". . . By initiating . . . programs . . . utilizing facilities, capabilities, expertise and experience of . . . industrial entities . . . which are appropriate. . . ."
P.L. 94-163, Energy Policy and Conservation Act of 1975, Title III, Part E, Sections 372, 375(e)	". . . Establish voluntary energy efficiency improvement targets . . . ." (for the most energy intensive industries) ". . . Prepare . . . an annual report . . . ."
P.L. 95-91, Department of Energy Organization Act of 1977, Title II, Section 203, Part 9	". . . Functions . . . include . . . implementation of major research and demonstration programs for the development of technologies and processes to reduce total energy consumption . . . ." (including industry)
P.L. 96-294, Energy Security Act of 1980, Title V, Subtitle G, Section 591	"To accelerate the research, development and demonstration of energy conserving activities designed to substantially increase productivity in industry . . . ."

To accomplish the missions assigned to it, the Industrial Conservation Program developed the following series of more specific objectives:

- To cost-share research, development, and demonstrations for industrial energy conservation technologies that appear to offer large potential for saving scarce fuels, and to encourage the private sector to implement and deploy such technologies as they were developed and/or demonstrated.

- To provide energy audits for small- and medium-size industrial firms by operating Energy Analysis and Diagnostic Centers, each conducting 40 audits per year.

The activities were selected so as not to duplicate developments that the private sector was pursuing or would be likely to pursue. Specific historical goals and objectives are shown in Table 32-1. As these projects are phased out during fiscal year 1982, reports will be prepared on the results to date in each one.

There are several other programs both inside and outside the Department that relate to the Industrial Conservation effort. The Energy Conversion and Utilization Technology Program* organized within the Department was directed at basic and applied research and development in support of energy conservation; the Heat Engines Branch of DOE's Coal Utilization Division** limited its focus to coal use. In addition, the Electric Power Research Institute has sponsored cogeneration demonstration programs, and the Gas Research Institute has its own industrial conservation demonstration program. There are also major Government efforts in research, development, and demonstration that relate to industrial energy conservation in Western Europe and Japan and are funded by the governments of those countries.

Program Results

Program accomplishments are shown in Table 32-1. The Industrial Conservation Program has provided support for 165 new technology developments deemed to be high risk; 8 of these are already penetrating the market, and it is estimated that they are already saving 6.5 trillion Btu's per year (0.0065 quad).

Results of technical innovations were widely disseminated through 24 workshops and seminars attended by more than 6,000 persons. More than 31,000 descriptive technical brochures were distributed. Small- to medium-sized concerns have been assisted by a total of 369 audits conducted through the Energy Analysis and Diagnostic Centers (EADC's). The progress of the industrial sector in industrial conservation was monitored through 935 companies that reported efficiency improvements and through 48 trade associations. Following are examples of the types of technology developments that were supported:

Energy Conservation in Metal Coating. A unique method was developed and tested whereby fumes from paint solvents are collected during the process of curing coils of sheet metal to which coatings have been applied. The trapped fumes are then used as fuel to fire the curing ovens themselves.

This technology can reduce the amount of natural gas required for coating coils by as much as 80 percent. Twenty-three such installations are in place and achieving energy savings approaching 2.5 trillion Btu's per year (0.0025 quad).

Plastic Waste to Fuel Oil. The Industrial Program also was involved in the successful development of a process to turn waste polypropylene plastic into the equivalent of distillate fuel oil. One plant using the process is now on line, producing 2 million gallons of fuel oil per year (0.0003 quad). The total potential production of this technology is estimated to be almost 0.02 quad per year.

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*See PAU #34, "Multi-Sector Conservation."
**See PAU #7, "Heat Engines."

Textile Foam Finishing. Still another idea supported by the program was a method of finishing fabrics that uses a foam rather than an aqueous process, so that considerably less heat is needed to dry the textile material. Eighteen foam systems are in place, processing more than 1 billion yards per year and saving an estimated 150 billion Btu's (0.00015 quad) annually. The total estimated potential for this technology is a saving of 58 trillion Btu's per year or the equivalent of 10 million barrels of oil (0.06 quad).

Granulated Fertilizer Production. A new process, employing pipe-cross reactors as a means of utilizing normally wasted heat, was developed under the auspices of the Industrial Conservation Program and introduced to the ammoniation-granulation sector of the fertilizer industry. It has the potential of completely eliminating the need for process steam and slashing the amount of energy used for drying by 80 percent. Twenty-eight such installations are in place and operating; they are presently saving 1.2 trillion Btu's per year (0.0012 quad). Potentially this technology might save almost 30 trillion Btu's per year, or 5 million barrels of oil equivalent (0.027 quad).

Efficient Slot Forge Furnace. A new, high-efficiency slot forge furnace has been developed that improves energy efficiency during operation by almost 70 percent and is able to burn residual oil instead of distillate. The 30 units already in operation are saving an estimated 600 billion Btu's per year (0.0006 quad). The total potential annual saving from full adoption of this technology is 12 trillion Btu's, or 2 million barrels of oil equivalent (0.011 quad).

The Industrial Conservation Program has had a direct impact on the industrial sector by creating new jobs for equipment manufacture, operation, and maintenance. It also has reduced the cost of U.S. goods and has made possible an increase in Federal tax revenues from increased corporate profitability.

The impacts on the environment, health, and safety have generally been positive. Increased utilization of waste materials eliminates solid waste disposal problems. Since only eight projects have moved into the marketplace fully thus far, it is too early to assess quantitatively the program's total long-term impact.

Projected Program Requirements

Congress has appropriated $28.8 million for fiscal year 1982. It is the Administration's view that further activities of this type can and will be accomplished by the private sector without additional Federal involvement.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(33) TRANSPORTATION CONSERVATION (CE)

Program Objectives

The transportation sector accounts for more than half of all U.S. petroleum consumption and is almost entirely dependent upon petroleum as its fuel source. The National Energy Policy Plan (NEPP) has a midrange projection of 9 million barrels per day (17.2 quads) of petroleum use by the transportation sector in the year 2000, but it is possible--with cost-effective technology improvements, fuel substitution, and additional conservation measures--that petroleum use for transportation by that year could be reduced 25 percent below the NEPP baseline.

The general goal of DOE's Transportation Conservation Program is to perform research and development related to vehicles and engines that will increase the fuel efficiency of the transportation system and allow it to switch from almost exclusive reliance on petroleum toward electricity and alternative fuels. The original legislative mandate was the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), which directed the Administrator to "advance energy conservation technologies, including . . . improvements in automobile design for increased efficiency . . . including investigation of the full range of alternatives to the internal combustion engine."

Additional acts provided greater focus on specific research and development, along with funds for operations. The purpose of the Automotive Propulsion Research and Development Act of 1978 (P.L. 95-238), for example, was to enhance competition among existing and alternative automotive propulsion systems and to supplement private industry research and development on advanced systems, giving priority attention to those with fuel flexibility. The rationale for a federally financed Vehicle Propulsion Program was that domestic vehicle manufacturers were devoting insufficient resources to research and development on advanced propulsion systems, especially in an era of controlled energy prices.

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 (P.L. 94-413), as amended by P.L. 95-238, declared that the policy of Congress was to encourage and support accelerated research of electric and hybrid technologies, to demonstrate the economic and technical practicability of electric and hybrid vehicles and to remove barriers to their use.

The Transportation System Utilization Program comprises several components, each of which has the support of a public law. The production and distribution of an automobile fuel economy guide is mandated by section 506(b) of the Energy Policy and Conservation Act of 1975 (P.L. 94-163). The promotion of voluntary and mandatory conservation programs was stated as a policy by section 5(b) of the Federal Energy Administration Act of 1974 (P.L. 93-275). The development of a standby conservation plan was mandated by section 213(a) of the Emergency Energy Conservation Act of 1979 (P.L. 96-102). The Alternative Fuels Utilization Program had legislative backing from section 101(15)(c) of the Automotive Propulsion Research and Development Act and the Methane Transportation Research, Development, and Demonstration Act of 1980 (P.L. 96-512).

One goal underlying several of the Department of Energy's transportation efforts has been to conduct research and development that, through cost-effective fuel efficiency improvements and fuel substitution, would assist the transportation sector in moving toward its long-term potential of a 25-percent saving in petroleum requirements, while maintaining personal mobility for Americans and protecting both human health and safety and the environment.

The specific objectives of the Transportation Conservation Program are depicted in Tables 33-1 and 33-2. Many methods of reducing transportation petroleum use have been used, but the Department's emphasis during fiscal year 1982 is on research and development of generic, high-risk, and high-payoff technology that private industry is unable or unwilling to undertake on its own.

Programs of advanced engine and electric vehicle research also are under way in Europe and Japan, where they receive government support. The foreign programs provide a competitive challenge to the well integrated research and development efforts of the U.S. Government and industry. Apart from those in which the Department of Energy is involved, the only significant U.S. Government-sponsored research and development effort aimed at conserving energy in the transportation sector is the $100-million-per-year program on aircraft fuel efficiency conducted by NASA.

With regard to alternative means of conservation in automotive transportation, the current DOE program has included materials to make all heat engines more efficient, advanced diesel engines, alternative-cycle heat engines, and electric and hybrid vehicles. With regard to fuel substitution, there has been research on both the replacement of petroleum by electricity (via the electric vehicle) and by alternative fuels (via modifications of conventional engines or their replacement by advanced heat engines that have greater flexibility in the fuels they can use).

<u>Program Results</u>

The original objectives of the Vehicle Propulsion Program were long run in nature, so many of the ultimate objectives have yet to be achieved. However, accomplishments of interim milestones in designing and testing alternative, fuel-flexible engines for use in transportation have added significantly to the U.S. technology base.

With respect to the gas turbine engine, significant progress has been made in ceramic materials and small-scale turbine aerodynamics during the past few years as a result of the Department's effort. Compressor and turbine efficiencies have been improved by several percentage points, and high-temperature ceramic materials were formed into intricate airfoil and rotor shapes that have been tested successfully in an engine environment for the first time. Progress in these technologies will apply also to a number of other commercial and military applications, such as cruise missile engines, gas turbines for small aircraft and helicopters, and other rotating machinery.

Stirling engine improvement over the last few years also has been significant. The MOD I Stirling engine has shown itself to be more than 50 percent more efficient than its predecessor. Additionally, improvements in seal technology, materials, and hydrogen permeability have increased the durability and reliability of the engine. Results either have met or exceeded the projected values, indicating that computer design programs developed in connection with the program are trustworthy. The Stirling engine improvements have spin-off benefits for other applications such as solar-electric generation, heat pumps, military ground power units, industrial process energy, and farm power.

Under a demonstration program carried out in cooperation with the Urban Mass Transit Administration and the Baltimore Mass Transit Administration, the Department placed a number of turbine buses into revenue operation. The desired fuel economy was not achieved, however, and this field testing demonstrated the need for ceramic parts. The demonstration project also revealed the importance (and lack) of an adequate infrastructure for maintenance.

In accordance with the Electric and Hybrid Vehicle Research, Development, and Demonstration Act, the original objectives of the Electric and Hybrid Vehicle (EHV) Program included a demonstration program, but the target of 10,000 demonstration vehicles envisioned by the act was never reached. However, as of the fall of 1981, 68 cost-sharing site operators were using about 1,000 electric vehicles, and the demonstration program had established a group of electric vehicle users (including the post office) who could make use of new automobiles, light trucks, and components as they became available. Another program objective was to assist small businesses, and this was done through competitive contract awards to produce state-of-the-art electric vehicles and through a loan guarantee program (as directed by the Electric and Hybrid Vehicle Research, Development, and Demonstration Act). EHV demonstrations also succeeded in stimulating similar demonstration programs by the Tennessee Valley Authority and the Electric Power Research Institute.

The 100-mile range for the electric vehicle now anticipated by 1984 will be substantially above the 30-mile range that existed in 1976, or even the range of 70 miles achieved in 1981 by the ETV-1 test vehicle. Progress has been made during the past 4 years in stimulating an electric vehicle program at General Motors, although General Motors' latest announcement of plans to produce a two-passenger electric vehicle in 1987 represents a delay of 2 years.

The original objectives of the Transportation System Utilization Program were numerous and diverse; some of the major ones are shown in Table 33-1. A course to train drivers in fuel efficiency (DECAT) was established in 1978, and by 1981 more than 3,000 drivers and 500 instructors had been trained. A survey of 102 graduates of the DECAT Program revealed that most respondents had conducted driver efficiency classes and that they planned to train more than 1,000 additional instructors, who would eventually train more than 200,000 other drivers.

In terms of recent changes in program focus, the Voluntary Truck and Bus Fuel Economy Information Program was first conducted jointly by the Department of Transportation and the Department of Energy, but is now being handled solely by the Transportation Department.

The Standby Federal Emergency Energy Conservation Plan required by the Emergency Energy Conservation Act was available for use in an emergency and as an example for states to follow in developing contingency plans. The plan was established in accordance with the statutory requirement.

The annual publication of the "Gas Mileage Guide" will continue through fiscal year 1982. More than 16 million copies of the guides have been produced and distributed in each of the past 4 years. A survey of guide use and its effect revealed that about 3 percent of new car buyers (about 300,000 per year) used information contained in the guide to help choose a new vehicle. Furthermore, it was discovered that these buyers tended to purchase a new vehicle with a fuel economy rating that was 2 mpg higher than the average of vehicles purchased by other buyers. Since similar information is circulated by private-sector publishers, the Department does not expect to continue publication beyond fiscal year 1982.

The major objective of the Alternative Fuels Utilization Program has been to ensure that new fuels are well suited to new or modified engine developments. A data base of new fuels has been established, and regular roundtable forums for engine manufacturers and fuel suppliers have been sponsored by the Department. The testing and evaluation of alcohol fuels, incidentally, have provided a firm foundation of research which is used by the Department's Office of Alcohol Fuels (see PAU #28, "Alcohol Fuels").

The ultimate beneficiaries of increased conservation in transportation have been the users of transportation services and the transportation system: 140 million drivers, thousands of businesses that ship goods, and more than 1 million truckers. The Nation as a whole benefits from reduced dependence on foreign petroleum supplies and from the lower world oil prices that result from reductions in U.S. demand for imported oil.

The four U.S. automobile manufacturers have programs through the cost-shared research and development contracts that each has had for vehicle propulsion. Likewise, GE-Chrysler, Ford, and the General Motors truck and coach division have cost-shared research and development on electric vehicles.

Beneficiaries of past outreach programs have been numerous. The program has distributed more than 6,000 reproducible "Gas Saver" kits, has shown the movie "Running on Empty" to more than 20 million people, and has distributed several million copies of "How to Save Gasoline and Money." Many persons have joined vanpools and have benefited by the adoption, in 47 states, of new insurance rates and classifications for vanpools.

A major issue to be considered in evaluating any Transportation Conservation Program is the effect on personal mobility and on the freight transportation system, because both of these play pivotal roles in the national economy. The transportation system accounts for about 18 percent of the Nation's gross national product. Problems of fuel availability and price increases have been and will continue to be offset somewhat by conservation efforts (both behavioral and efficiency improvements).

The introduction of advanced heat engines and/or electric vehicles is not likely to make much difference in terms of total employment, but the impacts should be positive. Both technologies are expected to benefit domestic vehicle manufacturers, thus improving the U.S. balance of trade and either maintaining or creating additional domestic jobs in the automotive and support industries. The cost to consumers should be reduced on the basis of miles traveled, because each user should have more options in choosing a vehicle or vehicle-mix that can optimize individual travel costs. Using alternative transportation fuels will make more domestic resources available to power vehicles and also will tend to reduce fuel prices.

Several beneficial environmental consequences might be expected in the long run. Substituting electric vehicles for those that use gasoline or diesel fuel can reduce the total tonnage of air pollutants, change their mix in a beneficial way, and shift their dispersal away from population centers. Certain fuels, such as alcohol, are also likely to yield lower levels of NO_x emissions.

Basic congressional objectives have been met in both the Vehicle Propulsion and EHV Programs. Advanced automobile propulsion systems have been funded, competition has been enhanced among existing and alternative automotive propulsion systems, and Federal funds have been used effectively to supplement research and development by private industry. Research on electric and hybrid vehicles has been accelerated, the current state-of-the-art vehicles have been demonstrated, and some barriers to the early introduction of electric and hybrid vehicles have been removed. The budget expenditures over the past 4 years are shown in Table 33-1.

<u>Projected Program Requirements</u>

Congress has appropriated $58.9 million for this program in fiscal year 1982. No funds are being requested for the Transportation Conservation Program in fiscal year 1983. With the decontrol of energy prices and other actions to free the energy marketplace, it is no longer necessary for the Federal Government to support technology research and development aimed at introducing new transportation technologies into the marketplace. The private sector will undertake technology-specific work when it can be shown to have an economic payoff to the company. The Federal Government will continue to support long-term basic and generic research for all energy conservation technologies. Some research being carried out in the Transportation Conservation Program will be moved to the Energy Conversion and Utilization Technologies Program in fiscal year 1983.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(34) MULTI-SECTOR CONSERVATION (CE)

In addition to energy conservation efforts that focus on one or another of the separate consumption sectors (residential, commercial, industrial, and transportation), some Department of Energy conservation programs deal with energy uses across the board. These "multi-sector" programs include the Energy Conversion and Utilization Technologies Program, the Energy-Related Inventions Programs, and the Appropriate Technology Program. Although they are not integrated programmatically, these three relatively small activities are treated within this single program analysis unit (PAU) because their diverse objectives are united by the single goal of energy conservation.

ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES PROGRAM

Program Objectives

The Energy Conversion and Utilization Technologies Program (ECUT) was formally established in fiscal year 1981 as a program consisting of research and exploratory development activities designed to produce generic technologies that could be applied in more efficient energy systems of all sorts. Appropriate segments of various ongoing Department of Energy program activities were joined into a single office, which also provides a working interface between the energy conservation programs discussed in PAU's covering Buildings and Community Systems (#31), Industrial Conservation (#32), and Transportation Conservation (#33), and the Basic Energy Sciences Program discussed in the Energy Supporting Research PAU (#38).

The foundations for the efforts united in ECUT can be traced to the Statement of Policy section of the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577), in which Congress declared its purpose "to establish and vigorously conduct a comprehensive, national program of basic and applied research and development, including but not limited to demonstrations of practical applications of all potentially beneficial energy sources and utilization technologies within the Energy Research and Development Administration." Later, this mandate was passed to the Department of Energy when the Department was organized.

The ECUT Program supports long-term, high-risk applied research and exploratory development necessary to ensure the availability of a future technology base that will enable a substantial increase in both the efficiency of energy conversion and utilization equipment and the increased use of noncritical fuels. It evaluates and screens innovative ideas from many sources.

The objectives of the ECUT Program are defined in terms of technological accomplishments that are relevant to private-sector efforts to develop specific systems; and, as Table 34-1 shows, the current focus is on improved heat engines, combustion equipment, heat exchangers, and industrial process equipment.

In launching ECUT activities during 1981, three projects were organized around work in progress that was transferred from other parts of the Department of Energy. These deal with engine combustion technology, closed cycle power systems, and physical processes. Several other projects (Direct Heating and Conversion, Chemical Processes, and Materials) were funded at minimal levels initially so that research opportunities could be identified, selected, and assigned priorities for future planning.

If funding of ECUT should be terminated, it is possible that some other Government agencies (such as the National Science Foundation or the National Bureau of Standards) may continue these activities. This, of course, would require some time. The private sector probably would not pursue these generic technology base research activities to improve energy conversion and utilization efficiency without stronger incentives than now exist. Some foreign governments actively pursue such energy research with their respective industrial partners.

Program Results

ECUT is a new program; since it undertakes long-term research and development, the degree to which it is meeting objectives can be ascertained in the short term only by its success in reaching intermediate milestones on schedule. As Table 34-1 indicates, some of these should be reached early in calendar year 1982.

As a result of the generic research sponsored by ECUT, benefits to energy consumers are difficult to ascertain.

No specific National Environmental Policy Act requirements need to be addressed at present because most of ECUT's projects are in the early development stages.

Projected Program Requirements

The ECUT appropriation for fiscal year 1982 is $8.3 million, although this amount will be enhanced for fiscal year 1983 since basic research from other conservation programs will be centralized in ECUT. Current objectives, including intermediate milestones, are given in Table 34-2. An increase or decrease by 10 percent from the anticipated funding levels would change the time frame for those milestones within the long-term research and development projects.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

ENERGY-RELATED INVENTIONS PROGRAM

Program Objectives

The Energy-Related Inventions Program was established by the Federal Nonnuclear Energy Research and Development Act, which now applies to the Department of Energy. The program objective from section 14 of that act was to ". . . (evaluate) all promising energy-related inventions--for the purpose of obtaining direct grants from the (ERDA) Administrator." The program gave attention "particularly (to) those (inventions) submitted by individual inventors and small companies." The congressional conference report directed the National Bureau of Standards (NBS) to keep ERDA advised of promising inventions that should be considered for inclusion in the energy research, development, and demonstration programs. Thus, the program has been a type of Small Business Innovation Research program. Initial technical screening, in-depth analysis, and invention selection at NBS has been followed by various kinds of grant support and technical assistance in the Department of Energy portion of the Inventions Program. No other Federal program currently provides support to individuals and small businesses specifically in the field of energy-related inventions.

The objectives of the program were to evaluate the technical merits of all energy-related inventions submitted; to provide assistance for research, development, and demonstration on selected inventions by individuals and small businesses; to encourage additional invention and innovation by individuals and small businesses by disseminating information about the program; and to maintain a cost-effective system of monitoring the technical progress of the inventions funded.

Program Results

Tables 34-1 and 34-2 chronicle the record of accomplishment over the past 4 years. Since 1978, NBS has evaluated 10,914 energy-saving inventions. Based on NBS recommendations, 115 inventions (about 1 percent--a fraction comparable to yields from similar programs in Great Britain and Denmark) have been awarded grants at a cost of approximately $8.8 million for an average grant of about $77,000.

Although it is too early to assess fully the effect of the program on the national energy scene, there are some indications of program success. A number of industrial applications have the potential for increasing productivity in such key processes as aluminum and steel production, oil-well drilling, and coal mining. Two of the grantees already are employing 300 more people than they were before receiving their grant awards. Three others have created a total of 300 additional jobs for either their industry or their licensees. A study by the Massachusetts Institute of Technology (MIT) concluded that the Inventions Program provides one of the few funding channels through which inventors can receive an objective hearing. MIT also found that a significant number of valuable ideas have been submitted to the program and "that the society returns on those that eventually come into public use appears likely to repay the Nation manyfold." Program support has helped small entrepreneurs to maintain their proprietary positions, and there is evidence that this is frequently the single most important method of ensuring that new products reach the marketplace.

Market penetration by an innovative product is a laborious process that normally takes 6 to 8 years, and the program has not been in existence that long. In accordance with the funds available, program policy has been for one-time-only assistance. Given these factors, the Inventions Program has had a modest but potentially significant impact.

Projected Program Requirements

The program has an appropriation of $5.2 million in fiscal year 1982 for the activities described above. A 10-percent increase in funding would make additional grants possible; 10 percent less funding would reduce the level of NBS activities. The program assists the private sector in developing worthwhile innovative ideas about energy-saving technologies that can come from individuals and small businesses. The program will be proposed for termination in fiscal year 1983 in line with the Administration's Economic Recovery Program which aims to improve the climate for investments, and thus improve the ability of inventors to find financial support.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

APPROPRIATE TECHNOLOGY PROGRAM

Program Objectives

"Appropriate technology" describes decentralized systems for producing or applying energy that are consciously matched in scale and nature to local needs and resources. In this regard, the program assists selected regions and particular commercial sectors of the economy. Examples include a low-powered wind generator for use at a remote site or some mechanism for using farm wastes as fuel. Special attention has been given to the use of renewable resources that are readily available, so--in addition to technology that conserves energy in the usual sense for residential, commercial, industrial, or transportation users--this program has concentrated on a variety of substitutes for "conventional" energy forms. By design, the program also has emphasized labor-intensive (rather than capital-intensive) systems. Congress authorized its establishment under the Energy Research and Development Administration Appropriation Authorization of 1977 (P.L. 95-39).

The Appropriate Technology Program has used grants to promote the development and demonstration of small-scale, decentralized, renewable energy systems that are environmentally sound; that use locally available material; that are simple to install, operate, and maintain; that satisfy local needs; and decrease community dependence on external energy sources. Grants for concept development have ranged up to $10,000 each, with as much as $50,000 being awarded for hardware development or demonstration. One of the program's objectives was to promote the diffusion of these technologies and to encourage their widespread replication.

Program Results

Since fiscal year 1978, the program's first year, the Department of Energy has evaluated nearly 45,000 proposals, selecting about 2,400 (5 percent) for funding at a total cost of $28 million. The average grant was about $12,000. Approximately 20 publications were released, about 50 workshops were conducted to encourage the initiation of successful projects, and approximately 150 final reports have been received from completed projects. Thus, the program has met its objective of supporting the research, development, and demonstration of a great variety of small-scale, decentralized renewable energy technologies by providing financial assistance.

This program has been concluded; but, because of the time lag in receiving information from completed projects, only limited information has been disseminated about actual accomplishments.

A study of the fiscal year 1979 program by the Lawrence Berkeley Laboratory concluded that projects funded in that year alone could save or displace a long-term total of 22.8 million barrels of oil equivalent (0.13 quad), assuming that each system continued to operate for about 20 years and that successful projects were copied by others. The program has also served to increase public awareness of conservation opportunities and small-scale renewable energy technologies, encouraging community involvement in demonstration projects.

Principal beneficiaries of program assistance have been individuals, small businesses, and Indian tribes.

Projected Program Requirements

The grant program has been terminated; no funds will be requested for fiscal year 1983 or beyond. Fiscal year 1981 was the last grant award cycle; however, since projects are funded at the end of the fiscal year for up to 24 months, some previously funded project activity will continue through fiscal year 1984. Congress has appropriated $3.0 million for fiscal year 1982 for monitoring existing projects and for disseminating information about lessons learned from the projects.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(35) STATE AND LOCAL PROGRAMS (CE)

Program Objectives

The Office of State and Local Programs has been responsible for administering grants, providing technical assistance, and offering guidance on energy conservation, energy outreach, energy efficiency, energy technologies, and alternative energy programs to state energy offices, local governments, small businesses, organizations, and individuals. The four specific state and local programs administered by this office are the Energy Extension Service; the State Energy Conservation Programs; the Weatherization Assistance Program; and the Schools and Hospitals and Buildings Owned by Units of Local Government and Public Care Institutions Grant Programs.

The four pieces of legislation that established these programs provided Federal direction and financial support for state and local governments in encouraging energy conservation. Plans for State Energy Conservation Programs were first described in the Energy Policy and Conservation Act of 1975 (P.L. 94-163), and supplemental plans were first described in the Energy Conservation and Production Act of 1976 (P.L. 94-385). The Energy Conservation and Production Act also established the low-income weatherization program. Formation of an Energy Extension Service in 1977 was the intent of the National Energy Extension Service Act of 1977 (P.L. 95-39). The National Energy Conservation Policy Act of 1978 (P.L. 95-619) contained authorizations for state utility plans, additional weatherization activities, grants for schools and hospitals, and local government and public care institutions grants program.

Energy Extension Service (EES). The goal of EES was to establish state energy outreach programs directed toward public institutions, small businesses, and individual energy consumers. The state programs were intended to provide personalized assistance to these energy users on energy-efficient technologies and other opportunities to reduce energy consumption and/or shift to renewable energy resources. Provisions were included in the National Energy Extension Service Act for program evaluation and technical assistance by the Department of Energy to states in support of their EES efforts, as well as for financial assistance to the states through Federal grants.

State Energy Conservation Program (SECP). Under SECP, states were to develop and implement plans designed to reduce projected 1980 energy consumption by 5 percent or more. Each state plan was required to include eight measures: lighting efficiency standards; ridesharing programs; energy-efficient procurement practices; building thermal efficiency standards; right turn on red; public energy education; intergovernmental coordination; and energy audits for buildings and industrial plants. In addition, state plans have included other measures to help achieve energy conservation goals--for example, beverage container regulations, energy management training, car-care projects, and woodburning stove programs. A related goal of SECP was to develop state capability to manage energy conservation activities, primarily through the establishment of state energy offices. In addition to financial assistance through grants, SECP has supported state efforts by providing technical assistance, training workshops, and information-sharing activities that enabled states to exchange program results.

Weatherization Assistance Program (WAP). The goal of the Weatherization Assistance Program is to make the modifications necessary to provide for energy efficiency in dwellings owned or occupied by low-income persons, particularly those who are elderly or handicapped. Weatherization of such dwellings can lower utility expenses for low-income owners or occupants, as well as conserve needed energy. The primary clients (the elderly, poor, and handicapped) could not have undertaken these conservation efforts on their own.

A primary historical objective of the Department's Weatherization Assistance Program was to award annual grants to 50 states, the District of Columbia, and 25 Native American tribal organizations to weatherize approximately 700,000 homes by the end of fiscal year 1981. This was to be in addition to the substantial number of homes weatherized by the Community Services Administration,* so that roughly one million U.S. homes would be weatherized under the two programs.

Schools and Hospitals and Buildings Owned by Units of Local Government and Public Care Institutions Grant Programs. Congress established these grant programs (also known collectively as the Institutional Conservation Programs) with the goal of providing financial assistance needed at the time to overcome unique barriers to energy conservation, based on the fiscal situations of tax-exempt institutions and local governments.

The institutional grant programs have had two phases. The first phase has provided grants to the states to enable them:

- To conduct preliminary energy audits of school and hospital buildings and buildings owned by units of local government and public care institutions to assess the number, types, and energy-use characteristics of those buildings for the purpose of developing state plans; and

- To provide energy audits to all interested schools, hospitals, and local government and public care institutions in the state, to help

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*From 1975 to 1978, the Community Services Administration (CSA) ran a similar program whose results have traditionally been included with the Department of Energy's because of the close relationship between the two programs. Although it is virtually impossible to give a precise figure for the CSA program (and although it showed great variation in the degree to which weatherization was accomplished), it is reasonable to estimate that a quarter of a million or more residential units were involved. The number may have been as high as 400,000. For the purpose of this program analysis unit, only DOE statistics are discussed.

them identify and implement energy conservation operating procedures.

The second phase has provided grants to enable:

- o States, schools, hospitals, and local government and public care institutions to undertake technical assistance projects (engineering studies of energy conservation potential) in school and hospital facilities; and

- o Schools and hospitals to acquire and install energy conservation measures in their facilities.

Program accomplishments for the various state and local programs are outlined in Table 35-1.

Program Results

Energy Extension Service (EES). Based in part on a favorable evaluation of the 2-year, 10-state pilot program, EES was expanded nationwide during fiscal year 1980. Fifty-seven states and territories have offered personalized assistance to energy users on practical, energy-saving opportunities. Services such as energy audits and self-help workshops were tailored by the states to the needs of homeowners, small businesses, local governments, and other public institutions. States were given broad flexibility in designing services, so that particular local needs could be met through the program and so that EES activities could be used to supplement or complement other conservation and renewable resource programs.

Sample EES clients* in the 10 pilot states saved the equivalent of 6,400 barrels of oil per day beyond what would have been saved without the program (0.0128 quad on an annual basis), and clients invested a total of $59.9 million more in energy conservation measures than did comparable nonclients.

In addition, the program had a multiplier effect in stimulating self-sustaining action by others. For example, a San Diego, California, program in which qualified senior citizens provide technical assistance to other senior citizens has been picked up on its own by communities throughout the state.

EES spearheaded a technical assistance concept and operation that pulled together existing resources, made them easily accessible to states, and encouraged the building of independent state capability for handling repetitive needs.

State Energy Conservation Program (SECP). The states reported to DOE that their savings from SECP in 1980 totaled 3.1 quads, about 4 percent of actual U.S. energy consumption for that year. However, this figure

*The sample included approximately 1,500 residential users, 500 small businesses, and 300 public institutions.

represented the total saving from all public and private energy conservation efforts and cannot be credited to SECP alone. For example, a more conservative analysis by the Department of Energy estimated that 33 million barrels of oil equivalent (about 0.2 quad) were saved by selected SECP Program measures during 1980. If this much more modest estimate is closer to the fact, it is still a significant savings over a number of years.

There were few state energy offices before SECP was created. Under the program, all states established or expanded their capabilities to plan, design, and implement a wide variety of energy conservation measures. Most of the eight required program measures are being implemented regularly nationwide, along with additional measures developed by the states themselves to encourage energy conservation. These include:

- State tax incentives to manufacturers and purchasers of solar equipment (Puerto Rico)

- Energy audits, improved energy management, conservation retrofits, and computerized monitoring of energy consumption in state buildings (Montana)

- Industrial consortia for exchange of information on fuel conversions, cogeneration, and other aspects of energy conservation (Missouri)

- Energy resources groups to implement procedures for energy-efficient procurement (Illinois)

- Recycled paper purchases (Maryland)

Weatherization Assistance Program. By the end of fiscal year 1981, an estimated 758,000 homes had been weatherized under the program since the Department of Energy was established. Assuming an annual saving per residence of about 4 barrels of oil equivalent (representing between 20 percent and 25 percent of average home heating use) this constitutes an overall saving of roughly 3 million barrels of oil equivalent (0.0175 quad). Although there is some deterioration in weatherstripping over time, most of these residential energy conservation measures are relatively permanent and the energy savings will continue to accrue for the lifetime of the affected dwellings.

Operational problems that slowed anticipated weatherization rates during most of the program's first 3 years were gradually alleviated through legislative, regulatory, and administrative changes. These changes provided greater flexibility in grant funding, hiring of labor, installation of interim weatherization measures, and provision for multifamily rental units.

The precise significance of this program to the Nation's health cannot be quantified. With more weatherproofed homes, low-income persons (particularly the elderly and handicapped) may be more comfortable and less susceptible to illnesses caused by excessive heat or cold. With reduced energy costs, they are financially better able to meet their medical and nutritional needs.

Schools and Hospitals and Buildings Owned by Units of Local Government and Public Care Institutions Grant Programs. By the end of fiscal year 1981, more than 125,000 institutional buildings had been audited under Phase I of this program. The measures instituted by the owners following these audits produced an estimated annual energy savings of 14.22 million barrels of oil equivalent (0.08 quad). Under Phase II, 22,441 buildings received grants for technical assistance and energy conservation measures. Annual savings from the activities undertaken pursuant to Phase II totals an estimated 17.8 million barrels of oil equivalent (0.1 quad). These savings should be realized each year since Phase II grants helped finance energy efficiency capital improvements to buildings and equipment.

The savings discussed above are estimated savings. The Department of Energy is designing a detailed survey of eligible institutions and local governments to determine what measures have been most effective in reducing energy use by institutions, to examine the types of actions that have been taken by grantees, and to quantify other program results. Preliminary reports from the field indicate that the savings to date have been highly cost effective. The portion of program funds going to hospitals also results in savings to the Federal Government through the Medicare/Medicaid program.

The greatest economic impact of these programs lies, of course, in the reduced operating costs for participating institutions. The energy conservation projects funded also have created design and construction jobs. The $225 million Federal grants obligated in these programs have resulted in a total investment of $450 million, which is more than 30 percent of the total value of all construction put in place for schools and hospitals in 1978.

Projected Program Requirements

Congress has appropriated $231.9 million in fiscal year 1982 for the four categories of state and local programs. These funds will be used to retrofit approximately 124,000 to 145,000 low-income homes under the Weatherization Assistance Program; to issue 170 grants under the EES and SECP programs; and to provide 1,000 technical assistance grants and energy conservation measures grants to schools and hospitals.

No funds, other than those requested for closeout activities, will be requested for the State and Local Programs in fiscal year 1983 because the Department believes that these programs will have achieved their original objectives by the end of fiscal year 1982. Table 35-2 summarizes the current program objectives and budget.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(36) ELECTRIC ENERGY SYSTEMS (CE)

The expanded application of electricity generated by domestically abundant resources can make this country less dependent on expensive and unreliable supplies of foreign oil. In every consumption sector, there are many cases in which it may pay to let electricity displace oil directly.

Not all electricity-generating plants are equally efficient and economical, however. A well-integrated electric power network, be it large or small, uses only the most desirable available generation resources at any given time; "baseload" powerplants are the more efficient and economical plants used to satisfy average continuous demand, while the less efficient and less economical "peaking" plants are held in reserve and brought on line to provide supplemental supplies during periods of high demand. Advanced technology in power transmission, system integration, and system control, as well as energy storage, enables a power network to function more effectively.

Program Objectives

The Electric Energy Systems Program (EES) was created to assist the private sector in accelerating the development of advanced technology options for the Nation's electric energy networks, methodologies for integrating new electric generating and storage technologies into the design and operations of electric utility systems, and ways to ensure the stability and efficiency of the country's increasingly complex interconnected electric energy system. Public concerns over health and safety, reliability, and cost savings led to initiation of innovative research in such areas as high-voltage systems, new materials, and sophisticated control methods.

EES research and development activities originated in 1970 in the Department of the Interior as the Underground Transmission Project. Under the guidance of the Electric Research Council, the scope of the program expanded quickly to high-voltage overhead transmission and to research in systems engineering. EES was transferred from the Interior Department to the Energy Research and Development Administration (ERDA) under the Energy Reorganization Act of 1974 (P.L. 93-438). At about that time, the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) identified the importance of and need for long-term improvements to the Nation's capability for generating, storing, and transmitting electric energy; and the act singled out, in particular, cryogenic transmission--the use of supercooled cables to increase transmission capacity. With this guidance, the role of EES was defined in the 1975 and 1976 ERDA National Plans for Energy Research and Development. Since then, the program was incorporated into DOE as a result of the Department of Energy Organization Act of 1977 (P.L. 95-91).

The principal objectives, activities, funding status, and performance of the program for fiscal years 1978 through 1981 are summarized in Table 36-1. The current program goals are outlined in Table 36-2. The primary concerns of the program have been the following:

- To accelerate the introduction of technology options that are critical for maintaining the country's electricity supply system, in both normal and emergency conditions, in a reliable, economic, and environmentally safe manner
- To develop improved methodologies for planning and controlling complex, high-power electric systems
- To support basic research on increasing the efficiency of electric energy supply and distribution, thus reducing primary energy use per unit of real GNP

The goals have not changed significantly over the life of the program, though a relatively recent shift from the historical research patterns has resulted from the uncertainty of electric utilities throughout the country concerning the effect of unconventional technologies on the electric network. New dispersed and intermittent electric generation sources and electric storage will require substantial changes in today's transmission and distribution systems, especially in their control and protection under varying operating conditions. The strategy of the program has been to concentrate on those research efforts that would contribute the most to meeting the above objectives and that the private sector would be least likely to undertake because of large financial risk.

No other Federal or domestic private sector programs conflict with EES objectives, though several have related objectives--for example, DOE's Energy Storage Program and the research and development programs of the electric utility industry, foreign and domestic corporations, and a few large electric utility companies. Within the Department of Energy, the EES program coordinates its activities with related programs through technical program planning and project management activities. Direct and frequent contacts have been maintained within DOE with the Health and Environmental Research Office, Bonneville Power Administration, the Economic Regulatory Administration, and renewable technology areas. For example, EES managers and staff have worked with other DOE programs devoted to the development of advanced electric generation and storage technologies to ensure that promising technologies can be effectively integrated into the electric system and that the performance and operating requirements of the system are accounted for in the development of these specific technologies.

In addition, close coordination is maintained with the Electric Power Research Institute and other industry and state research groups. This minimizes duplication in research activities, ensures that utility system requirements and constraints are accounted for in electric generation, storage, and end-use technology development programs, and ensures that timely research is carried out by EES to resolve critical technical problems of integrating new technologies into the electric system.

Program Results

The objective of the Electric Energy Systems Program to help improve national electric power planning and delivery has been partially reached through the research achievements that are detailed in Table 36-1. Some of the more noteworthy achievements, and the rationale for undertaking these particular activities, are the following:

- About 10 percent of total electric power generation is lost in the delivery system; this amounts to about 2.2 quads annually. Ongoing research on high-efficiency materials has the potential to cut electrical delivery losses throughout all segments of the system by 15 percent by the year 2000, primarily by reducing metallic core and winding losses in distribution transformers.

- The need to deliver large amounts of electric power from outlying generating plants into congested urban environments--where prohibitive land costs for adequate rights-of-way as well as aesthetic objections often preclude the use of overhead transmission lines--calls for the development of a high-capacity underground transmission alternative. EES has done some research on the development of a superconducting, cryogenic cable which not only will minimize resistive electrical losses but also will combine higher efficiency with smaller size. In fiscal year 1981, this activity resulted in the fabrication of the world's first long-length (100-meter) superconducting cable.

- Storing lower cost electricity when demand is low and releasing it during periods of peak demand is one way to limit the use of less economical peakload powerplants and conserve scarcer primary fuels. EES supported efforts to test and evaluate the use of batteries for such purposes as load leveling. Construction of the Battery Energy Storage Test Facility in New Jersey was completed in fiscal year 1981; this provides an opportunity to perform engineering analyses of advanced battery applications in an operating utility grid.

- To operate successfully with conventional power sources, new small-scale electric generating sources and storage devices require different distribution system hardware and software. EES helped develop distribution concepts and advanced communications for effectively integrating dispersed and intermittent electric generation into systems designed for central generation.

- Potential perturbations in large powerplant generators operating synchronously in an electric system are difficult to analyze. EES helped develop new mathematical theory for understanding the interaction of multiple large generators in a complex interconnected system. Software to provide automatic generator control was installed on the Wisconsin Electric Power utility system with the objectives of improving system-wide efficiency and reducing plant maintenance costs.

Virtually all projects have involved industry and university participation. In those research activities where utilities and equipment manufacturers are participating, cost sharing is negotiated at a level commensurate with risk and benefits. EES has leveraged private sector research dollars through cost-shared contracts of up to 30 percent of total program funding. This results in turning over the engineering development and application work to the private sector at the earliest possible date. University projects are fully funded by EES to bridge the gap between advanced theory development and applications for critical technical problems.

The general population benefits from improved electric energy systems through the efforts to make available more efficient, less costly, and more reliable power supplies; the utility industry and its vendors benefit from EES subsidies for advanced technology development. EES program achievements are particularly important to the electric industry because of the desire of utilities to reduce the cost of electric power and of equipment suppliers to establish new markets.

Projected Program Requirements

Congress has appropriated $24.3 million for fiscal year 1982, which will be used to complete the highest priority research and lead to an orderly completion of all projects by fiscal year 1983. A 10-percent increase in funding would permit a slower program phaseout. A 10-percent decrease would accelerate it.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(37) ENERGY STORAGE SYSTEMS (CE)

Energy storage devices have an extremely broad range of potential applications. Electric utilities can use them to store electricity when demand for power is low and release electricity when demand for power is high, thus leveling load and reducing the need to build peaking capacity which burns expensive oil and natural gas. Residential and commercial buildings can use energy storage devices to store solar heat and electricity when the Sun is not shining. Where utilities have introduced "time-of-day" electric rates, buildings and factories can use energy storage devices to store power when rates are low and release power when rates are high. Industry can use energy storage devices to utilize heat that would be wasted in the absence of such devices, thus improving the efficiency of manufacturing. Vehicles can use energy storage devices to run on electricity instead of increasingly scarce petroleum.

However, in order for any application of energy storage devices to be broadly realized, the devices must function reliably and reduce costs. While the reliability and cost of many energy storage devices have significantly improved in recent years, they will need to improve much more before most applications of energy storage services become widespread.

Program Objectives

The original goal of the Energy Storage Systems Program was to develop and demonstrate improved energy storage technologies in cooperation with industry. In the area of electrochemical or battery storage, desired improvements included increased battery lifetime, increased energy storage and power output per unit of battery weight, and reduced cost. In the area of physical and chemical storage, improvements were sought in technologies for storage through underground compression of air, underground pumping of water, superconducting magnets, phase change of water and other materials, heat pumps, flywheels, and hydrogen. Such improvements were to reduce petroleum use by increasing the efficiency with which electric utilities use their generating capacity, by enabling intermittent energy sources like wind and photovoltaics to provide continuous service, by encouraging the manufacture and use of electric vehicles, and by increasing the productivity of industrial machinery. Specific objectives for improvements are detailed in Table 37-1.

The first legislative mandate for the development and demonstration of energy storage technologies was the Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409), which directed the development and demonstration of thermal storage systems "for use in residential dwellings." Soon afterwards, Congress passed the Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577). Section 6 of this act directed "investigation of the full range of alternatives to the internal combustion engine," one alternative being the electric battery. It also directed the demonstration of "storage systems to allow more efficient load following" by electric utilities. Subsequently, efforts to develop and demonstrate energy storage systems were reinforced by the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 (P.L. 94-413); the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 (P.L. 95-590); and the Energy Security Act of 1980 (P.L. 96-294).

The current goal of the Energy Storage Systems Program, through the end of fiscal year 1982, is to help develop high-risk energy storage technologies that industry will clearly not develop on its own. In this context, high risk means costly, uncertain of success, and long in lead-time prior to widespread use. Emphasis is thus being placed on long-term research and development. Projects that are low in risk are being phased out. It is assumed that development of worthwhile low-risk projects will be undertaken by private industry.

Improved energy storage is already being fostered not only by the Energy Storage Systems Program, but also by other Federal programs, by private firms, and by foreign countries. Related Federal programs are carefully integrated with the efforts of the Energy Storage Systems Program through such organizations as the Department of Energy Hydrogen Energy Coordinating Committee, the Department of Energy Materials Coordinating Committee, the Electric and Hybrid Vehicle Annual Review Group, and the Interagency Power Information Center. The Department of Energy's program and other Federal storage programs are coordinated with private storage efforts through such groups as the National Ad Hoc Battery Advisory Committee. Storage work in the United States is coordinated with storage work in other nations under the auspices of the International Energy Agency.

The main alternative to the Energy Storage Systems Program is to rely upon the private sector for research and development of energy storage to be conducted. Private research and development is promoted by the favorable tax treatment afforded to investment under the Economic Recovery Tax Act of 1981 (P.L. 97-34).

Program Results

The Energy Storage Systems Program has pursued an extensive agenda of research, development, and demonstration that spans the full range of energy storage technologies and applications. Pursuit of this agenda has caused many energy storage systems to increase substantially in reliability and decline significantly in cost. Indeed, it has caused a number of energy storage systems to become so sufficiently developed that their further development has been taken over by private industry. The accomplishments and costs of the Energy Storage Systems Program are detailed in Table 37-1.

Electrochemical storage systems that have been developed by the Energy Storage Systems Program include improved versions of lead-acid, zinc-bromine, nickel-iron, nickel-zinc, sodium-sulfur, metal-air, and lithium-metal sulfide batteries, as well as improved oxygen electrodes. Research conducted by the program has resulted in understanding how to build more efficient Hall (aluminum production) cells. The program has also built a facility to test batteries for utility load leveling.

- A zinc-bromine battery that stores a total of 10 kilowatt-hours of electrical energy and stores 60 watt-hours for each kilogram of battery weight (Wh/kg) has been shown capable of lasting for 160 charge-discharge cycles. With further improvements in cost and lifetime (number of cycles), zinc-bromine batteries someday may be used widely to store solar energy from wind or photovoltaics.

- A lithium-metal sulfide battery has been shown capable of simultaneously obtaining an energy density of 90 Wh/kg, a power density of 90 watts per kilogram of weight (W/kg) (as opposed to 60 W/kg in 1978), and a lifetime of 400 cycles (as opposed to 80 cycles in 1978). Based on progress to date, there are grounds for optimism that a lithium-metal sulfide battery with an energy density of 125 Wh/kg, a power density of 150 W/kg, and a lifetime of 800 cycles can be produced by 1990. Such a battery could power an economical electric vehicle that would accelerate sharply and run 150 miles between rechargings.

- An improved oxygen electrode has been developed to improve the efficiency of energy use in the chlor-alkali industry, and an improved Hall cell has been researched to improve the efficiency of energy use in the aluminum industry. Since these two industries use 90 percent of the electricity consumed in the industrial electrolytic sector, the energy savings from the devices should be substantial.

- The Battery Energy Storage Test (BEST) facility has been built to demonstrate the practicality of using batteries to level electric utility loads. The batteries charge from baseload capacity when demand is low (at night) and discharge to displace peaking capacity when demand is high (during the day). Beginning in fiscal year 1982, the BEST facility will be funded and operated entirely by the Electric Power Research Institute and Pacific Gas and Electric.

Physical storage systems that have been developed by the Energy Storage Systems Program include improved systems for flywheel braking of electric vehicles, superconducting magnetic energy storage, compressed air energy storage, underground pumped hydroelectric storage, and thermal energy storage.

- Flywheel prototypes for braking vehicles have attained an energy density of 88 Wh/kg. By storing kinetic energy from vehicle motion prior to braking, such prototypes may increase the range of electric vehicles by 25 percent and reduce fuel consumption in conventional vehicles by 50 percent in urban use.

- A superconducting magnetic energy storage system with 30 megajoules (8.3 kilowatt-hours) of capacity is to be completed and tested by 1983. The components of this system have all been designed and fabricated. A system that is 100,000 times larger and works on the same principles someday may prove practical for utility load leveling.

- Compressed Air Energy Storage has been furthered by computer modeling and field work that has clarified the type of caverns that are stable enough to provide such storage safely and the type of techniques that are needed to utilize such storage economically.

- Underground Pumped Hydroelectric (UPH) storage has been enhanced by development of high-head turbines, which can generate power from water that falls over 3,000 feet. The greater the distance water is allowed to drop, the greater the energy it releases and the more power it can generate. Improved UPH systems afford a near-term mechanism for utility load leveling in areas with flat terrain. All further development of high-head turbines has been transferred to the Electric Power Research Institute.

- Thermal Energy Storage has been advanced in a number of forms. Engineering tests have shown that molten nitrate salt can be used to store energy from centralized solar thermal-electric powerplants. Field tests have established that aquifers can be used to store heat in the summer for use in the winter and store chill in the winter for use in the summer with a high degree of recovery of heat or chill stored. A study covering a large sample of homes has established that consumer-owned thermal energy storage systems are economical for utility load leveling in the near term; further development of such systems has been transferred to the private sector. Thermal energy storage technology for heat recovery has been transferred to the paper and pulp industry.

Chemical storage systems that have been researched or developed by the Energy Storage Systems Program include improved chemical heat pumps and improved systems for producing, storing, and transmitting hydrogen.

- A chemical heat pump has been developed that uses methanol and calcium chloride as working materials. It moves 20,000 Btu's of heat per hour, stores 100,000 Btu's of heat, and operates for 100 cycles. Such a heat pump can increase the efficiency of heating and cooling in buildings. Because such a heat pump has been proven conceptually sound, its further development is being transferred to the private sector.

- Hydrogen storage has been advanced by improvements in the efficiency of electrolysis, thermochemical cycles, and other techniques for hydrogen production. It has also been advanced by studies of how best to store and transport hydrogen safely.

The Energy Storage Systems Program has a broad range of beneficiaries including industry, utilities, and consumers. Industry has gained from the development of thermal energy storage for waste heat recovery in the processing of paper and pulp, an improved oxygen electrode for use in making chlor-alkali products, and an improved Hall cell for manufacturing aluminum. Utilities have gained from refinement of centralized storage with batteries, compressed air, and pumped water. Consumers have gained from improved systems for storage of solar heat. In the future, the number of beneficiaries may be expected to expand as storage systems for waste heat recovery, utility load leveling, solar energy use, and electric vehicles increase in reliability and decline in cost.

Improved energy storage systems have a positive impact on the national economy. They are generally introduced to electricity-generating plants, factories, buildings, and vehicles only when their introduction reduces costs. Thus, to the extent improved energy storage systems are utilized, they raise productivity and reduce inflation. By lowering the costs of electricity generation and manufacturing processes, they also enhance the competitiveness of U.S. goods on the international market.

Environmental impact studies have shown that storage technologies tend, on balance, to have a desirable impact on health and safety. With the exception of hydrogen, the materials involved in storage technologies are materials with which there is long experience in safe handling. Hydrogen is not likely to become a widespread storage medium until means are found to transport it safely and economically. Electric vehicles clearly operate much more cleanly than conventional vehicles. In industry, use of energy storage systems for waste heat recovery should reduce pollution and thermal loading of the atmosphere by reducing combustion of natural gas and fuel oil.

The Energy Storage Systems Program is implementing the major intent of the legislation enacted by Congress. Table 37-1 shows the continuous progress that has been made toward the objectives since the program's inception. Performance and accomplishments for the years 1978 through 1981 are also summarized in Table 37-1.

Projected Program Requirements

The Energy Storage Systems Program has received appropriations of $32.2 million for fiscal year 1982. No funds will be requested for this program in fiscal year 1983. The goals and objectives of the fiscal year 1982 program are detailed in Table 37-2. This funding will allow research to proceed on new battery components, improvements in battery component stability, and characterization of battery materials; will continue development of batteries for electric vehicles, batteries for use in conjunction with photovoltaics, and thermal energy storage systems and chemical heat pumps for heating and cooling of buildings; and will permit further improvement in electrolytic and thermochemical processes for hydrogen production, rotor design for flywheels, underground storage systems, and magnetic storage systems. These activities will be phased out during fiscal year 1982 in an orderly manner.

A 10-percent increase or decrease in the Energy Storage Systems Program's fiscal year 1982 budget would amount to $3.2 million. An increase of this size would be applied to current electrochemical projects and to new work on hydrogen storage and distribution. A decrease of this magnitude would stop work on lithium-metal sulfide batteries and compressed air energy storage.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

3. Supporting Programs

OVERVIEW

Research and development efforts aimed directly at enhancing energy supplies and improving energy efficiency require supporting activities that both expand the foundation of knowledge on which these efforts are built and also facilitate the safe integration of energy technologies into the marketplace. The Department of Energy's activities in energy supporting research and those that investigate environmental, health, and safety issues are necessary adjuncts to its efforts to help resolve the Nation's energy problems. The Administration is committed to the basic goals of both these major support areas.

There is complete agreement between the Department's historical and current views of the role of energy supporting research in energy policy. In many cases, technological advances will hinge partly on knowledge gained from research conducted in such basic areas as nuclear sciences, materials sciences, chemistry, engineering, mathematics, and biology. Thus, the overriding goal of the Energy Supporting Research Program has been--and is now--to help produce this fundamental knowledge. Related goals are to enhance the training of future energy professionals; provide the Department with independent, objective analyses of research and technical activities; and rehabilitate and replace the Department's deteriorated general support facilities needed to continue the operation of DOE's laboratories, which, along with the universities, conduct most energy-related research.

Federal support of scientific research is especially important and appropriate. Given its great cost, long-term nature, and the fact that its applications are usually generic, or are often not evident at the outset, basic energy science is unlikely to attract private enterprise. But the Nation clearly needs to pursue a deeper understanding of the basic sciences; and, in the absence of private sector initiatives, this pursuit becomes a matter of national interest.

Similarly, it is in the national interest to achieve a reasonable balance between energy values and environmental values. The Department of Energy Organization Act of 1977 (P.L. 95-91) clearly expressed the concern of Congress about the environmental, safety, and health implications of the Department's activities. The act required the Department to incorporate "national environmental goals in the formulation and implementation of energy programs, and to advance the goals of restoring, protecting, and enhancing environmental quality, and assuring public health and safety."

This concern has been translated into a number of historical and current programs designed to achieve an effective level of environmental protection, safety, and health protection for all departmental operating facilities; to ensure compliance with environmental, safety, and health laws; to implement quality assurance in the Department's energy programs and in its contractor-operated facilities; to support remedial actions related to past Government nuclear operations; to seek a comprehensive understanding of human health, genetic, and environmental implications of energy technology development; and to conduct research enhancing the beneficial applications of radiation, radionuclides, and stable isotopes in the diagnosis and treatment of human diseases. The Administration is committed to these goals. Additionally, by streamlining administrative processes, reducing decision-making delay, and clearly weighing economic costs against effectiveness, the Administration seeks to minimize uncertainties on all sides in specific cases and to resolve conflicts involving energy and environmental issues according to an informed public consensus.

(38) ENERGY SUPPORTING RESEARCH (ER)

Program Objectives

Energy Supporting Research encompasses four subprograms: Basic Energy Sciences (BES), University Research Support (URS), Energy Research Analyses (ERA), and Multiprogram General Purpose Facilities (MGPF).

Of the four subprograms, BES has the most significant long-range potential impact on U.S. energy needs. Designed to provide the fundamental scientific and engineering base on which the Nation's future energy options depend, BES pursues knowledge and insight leading to new and improved processes and techniques by sponsoring research in the physical and biological sciences, geosciences, engineering, and mathematics. The products of research in these disciplines are the data and new concepts on which developments in the applied energy technologies are based.

The Basic Energy Sciences Program supports more than 1,000 research projects in nearly every field of modern science. Approximately 70 percent of this research is carried out at laboratories, 26 percent at universities, and 4 percent at other institutions.

Research in nuclear science advances knowledge about the behavior and properties of nuclei which can be applied to the development of fission and fusion energy systems, as well as to biomedical and environmental research. It also provides for the production and domestic and international distribution of isotopes for research, medical, and industrial purposes.

Research in the material sciences is aimed at developing an improved understanding of materials-related phenomena and properties that are often limiting factors in the development of new energy systems, as well as in the performance of existing ones.

Chemical sciences research covers a wide range of topics, including the chemical properties of solids such as coal; energy-related phenomena involving liquids, gases, and plasmas; and the behavior of submicroscopic particles such as molecules, atoms, ions, and electrons. This research will lead to an increased understanding of the chemical and physical properties and processes that affect nearly all energy technologies.

The engineering, mathematical, and geosciences activity joins three largely distinct research efforts. Engineering research is focused along two lines: the advancement of generic engineering science needed for a variety of applications in energy production facilities and engineering for increased energy efficiency. The applied mathematical effort focuses on the equations, computer algorithms, information analysis methods, and advanced computer concepts undergirding every aspect of energy technology development. The basic research in geosciences addresses problems associated with locating, defining, and extracting energy resources and disposing of wastes from energy production processes.

Biological energy research provides fundamental data and understanding related to biological energy conversion for ultimate energy use in biomass or other systems. The advanced energy projects activity complements other BES activities by exploring the feasibility of novel, often interdisciplinary energy-related concepts still at an early stage of scientific definition and, therefore, unlikely to be developed by industry. Although such concepts entail a high degree of risk, they have the potential for high payoff.

Basic research in most areas pertinent to DOE's mission requires highly sophisticated state-of-the-art equipment and facilities. Such facilities require a commitment to adequate funding for their operation in addition to the funding of the various research projects that rely on their availability. A number of these facilities are unique to the United States and are required for forefront research extending beyond those areas of highest priority for energy research.

University Research Support carries out several interrelated efforts involving energy-related education and manpower development at secondary school and college levels. These efforts support, in part, the legislative mandate of the Department of Energy Organization Act of 1977 (P.L. 95-91) which requires the Director of Energy Research to advise the Secretary of Energy about education and training activities. Originally, the program's goal was to increase and strengthen the involvement of colleges and universities in the national energy research and development effort. In fiscal year 1981, following the transfer and consolidation of a number of education-related efforts and the reorientation of the Department's overall mission, the principal goal of URS was focused on the need to increase the supply and enhance the quality of professional-level manpower available for both current and future energy research and technology development programs. URS program activities in support of this goal include maintaining a small number of energy research and training programs involving faculty and students at smaller colleges; ensuring a minimum level capacity for nuclear research and training by supporting the purchase of fuel for university nuclear reactors; utilizing the unique facilities and equipment at the Department's multiprogram laboratories for faculty/student research and training; providing support for graduate traineeships in selected, critically important engineering disciplines; and providing opportunities for secondary school teachers to learn about energy research topics for classroom use.

The Energy Research Analyses and Multiprogram General Purpose Facilities subprograms carry out activities in support of the Director of Energy Research's mandate to monitor and provide advice on the Department's research and development programs and to advise on facilities at the multiprogram nonweapons laboratories. The current goal of Energy Research Analyses is to provide the Department with independent, objective technical analyses and assessments of research and technical activities and needs.

The specific objectives are to monitor the DOE research and development program, goals, milestones, and objectives; to evaluate the technical performance of specified technologies and review estimates of their potential relative to alternative technologies; to coordinate departmental basic and applied research planning; and to provide a Department of Energy interface with other Government research and development programs to ensure coordinated Federal research. This activity also supports the Energy Research Advisory Board, a committee of outside experts chartered to provide advice to the Secretary on a wide range of energy research and development issues.

MGPF's goal is to rehabilitate and replace the deteriorated, unreliable, or otherwise inadequate general support facilities required to continue the operation of the Department's multiprogram laboratories. These facilities include roads, railroads, utilities, and support buildings such as laboratories, offices, shops, and warehouses. A separate objective is to develop a comprehensive program strategy and a process for assessing requirements and evaluating and selecting construction projects.

In all four cases, there are no Federal or private sector programs that duplicate DOE's activities. While the role of the Basic Energy Sciences Program is established by legislation, some of the objectives could be accomplished in part through other Federal agencies (for example, the National Science Foundation, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration). However, only through close and continuous interaction with energy technology programs can the mission of this program be accomplished effectively. Additionally, care would be needed to ensure that unique facilities at present DOE laboratories find appropriate sponsors. Alternatives to the URS activity include assigning individual manpower development responsibilities to specific technology program offices or relying on market forces. Alternative ways to accomplish the Energy Research Analyses effort include locating this activity in program offices, in other Federal agencies, or in the private sector. Alternatives to the Multiprogram General Purpose Facilities Program include reduction of workload at the laboratories, continued operation under conditions not in compliance with health and safety regulations, or leasing of facilities.

The legislative mandate for Basic Energy Sciences has its roots in the Atomic Energy Act of 1954 (P.L. 83-703), which assigned to the Atomic Energy Commission (AEC) responsibility for conducting basic research relevant to atomic energy. BES is a direct descendant of the original research organization established under the AEC. In 1971, the legislative authority of the AEC was expanded to permit the use of AEC facilities and capabilities to conduct research in all energy fields. In the Energy Reorganization Act of 1974 (P.L. 93-438), the Energy Research and Development Administration (ERDA--AEC's successor) was charged with assuming "AEC's role in connection with its physical research program, a long-range basic effort to further man's understanding of the natural laws and phenomena governing matter." When the Department of Energy was established in October 1977, the scope of Basic Energy Sciences was further expanded. At the same time, it was administratively assigned to the Director of Energy Research.

University Research Support also has its roots in the Atomic Energy Act of 1954, which authorized support for university-based research and training activities and support for reactors and other facilities used for research and training on college campuses. ERDA's organic legislation expanded that mandate by assigning responsibility "to help assure an adequate supply of manpower for the accomplishment of energy research and development programs by sponsoring and assisting in education and training activities in institutions of high education." Finally, the legislation establishing DOE made the Director of Energy Research responsible for advising the Secretary on "education and training activities required for effective short- and long-term basic and applied research activities of the Department."

The Department of Energy Organization Act transferred the functions of ERDA to the Department of Energy. This act assigned several monitoring and advisory functions to the Director of Energy Research. These include responsibility for advising the Secretary on the Department's physical research programs; on undesirable duplications or gaps in the Department's energy research and development programs; on the well-being and management of the nonweapons multiprogram laboratories; on education and training activities; and on mechanisms of financial assistance required for effective long-term basic and applied research. Energy Research Analyses and Multiprogram General Purpose Facilities are carried out, in part, under authority granted by the Department of Energy Organization Act.

Program Results

The health of the U.S. economy and its ability to increase productivity depend on a variety of factors, including scientific and technological advances that can lead to new and improved technologies. Through its support of research at laboratories and universities across the country, Basic Energy Sciences has had a positive long-term and pervasive impact on the Nation.

Among other benefits, BES recently contributed to marked improvements in the ability to predict the consequences of nuclear reactor accidents and the possible easing of nuclear plant siting restrictions as a result of research on the fate of fission-product iodine. It also helped develop high-strength steel alloys for potential use in automobiles and extended the lifetimes of catalysts used in coal gasification.

Although Basic Energy Sciences has grown annually at a rate of about 3 percent since 1977, expansion into new areas of research occurred at the expense of existing programs, the closing of two nuclear research reactors, and a reduction in nuclear-related work. During the 1977-81 period, work commenced on advanced energy projects, biological energy research, and the engineering, mathematics, and geosciences disciplines. Because none of these activities reached optimum size during the 4-year review period, it has been possible only to establish roots in key research areas.

The URS subprogram strengthened and expanded the energy research and manpower development capabilities of 22 universities and colleges (including [illegible] minority schools) over the 4-year Title X review period. The purpose of this effort was to provide opportunities for a small number of universities to increase their contributions to the Nation's energy research and development program by providing seed money for small-scale, exploratory, or proof-of-concept research on advanced scientific and technical concepts carried out by both junior and senior researchers. More than two-thirds of the individual exploratory research projects supported by URS were subsequently funded for followup research by other DOE program offices or by private industry. An exploratory research project supported by URS at one university led to a major materials research program focused on technology problems. The Department of Defense and private industry also contributed funds to this effort.

A second major URS impact was the maintenance of a core nuclear research and manpower development capability in the university community. This was accomplished by supporting the purchase of nuclear fuel and defraying costs associated with the operation of 30 such reactors. An average of 2,000 college students and faculty members each year gained firsthand knowledge about energy research and development through participation in specialized training and research programs using the unique resources of the Department's laboratories and its contractor facilities. An additional 2,000 secondary school teachers received information on energy research each year for use in teaching energy-related subjects.

The major impact of the Energy Research Analyses subprogram was improved efficiency in the Department's management and assessments of its research and development programs. Environmental research, magnetohydrodynamics, battery storage, and biomass were among the programs assessed during the past 2 years. The Energy Research Advisory Board transmitted 15 formal reports to the Department on topics ranging from the Strategic Petroleum Reserve to gasohol and is presently working on major studies of biomass, research and development priorities, and DOE multiprogram laboratories.

This subprogram formerly consisted of several activities, two of which have been terminated. Although its remaining baseline element was renamed Research Program Analyses (formerly Assessment Projects), the thrust of that element is unchanged. A second element involved the evaluation of the Satellite Power System (SPS) concept. The resultant study recommended that the United States not embark on a SPS program and that all related activities at the Department of Energy cease. The element was therefore terminated in fiscal year 1980.

A third element, Advanced Technology Projects, was terminated in fiscal year 1981. The reorientation in the Department toward long-range, high-risk and high-payoff research caused the program offices to increase their activity in advanced concept development. This created an overlap that was resolved upon termination of the Advanced Technology Projects program element.

Multiprogram General Purpose Facilities made its initial contribution in fiscal year 1981 by embarking on 13 projects to correct deteriorating laboratory facilities. Among them were fire safety improvements, replacement of deteriorated and inadequate laboratory and office space, power system improvements, and upgrading and replacement of roofs and mechanical systems. The fiscal year 1982 budget provides for continuation of eight of the fiscal year 1981 projects and for the initiation of four new projects. These include replacement of wornout boilers, corrections of unsafe road and railroad conditions, and replacement of a security facility and mechanical systems.

Projected Program Requirements

Of the total budget of $305.6 million for Energy Supporting Research, $256.1 million is allocated for Basic Energy Sciences which supports core research in the chemical, materials, and nuclear sciences, and in mathematics, engineering, and geosciences. This amount allows for responsible increases in the newer biological energy research, engineering, mathematical, and geosciences activities and for expansion of efforts to explore new concepts under the advanced energy projects element. It also includes continued increasing emphasis in high-temperature materials, chemistry and physics of combustion processes, chemical structure and behavior of coal, catalytic mechanisms and surface phenomena, photochemistry, and synchrotron research and facility operations. The Combustion Research Facility and the research reactors will operate at the current level of effort. The construction of the National Synchrotron Light Source is expected to be completed.

Additional funds would allow operation and support of research at new facilities at closer to optimum levels, and additional support for the new BES activities. A modest reduction in funding would require cutting back core research below the fiscal year 1981 level in the chemical, materials, nuclear, mathematical, and geosciences disciplines. Such a cutback would also prevent planned growth in selected new high-priority research areas in the engineering research, biological energy research, and advanced energy projects areas. Finally, such a reduction would require curtailed operations at selected research facilities (including university accelerators) as well as phaseout of operations of the newly completed intense pulsed neutron source facility.

During the same period, the operation of facilities consumed a large and increasing share of the program budget. The facilities are energy-intensive, so their cost increase (which invariably exceeded inflation) was met at the expense of the core program. Any further decrease in funding would have a detrimental impact on the facilities required to maintain BES research capabilities and on the core program. BES is fulfilling an identified national need for knowledge and understanding of energy problems and laying the foundation for future technologies. The need for research is expanding and many new opportunities have been identified. A viable long-range energy research program is necessary for future technological development.

In fiscal year 1982, the URS subprogram will carry out a small number of joint projects aimed at enhancing the flow of university research results to industry. Plans have been made to increase the number of university engineering faculty and students participating in the University Laboratory Cooperative Program and to continue the development of an operational manpower information system capable of interrelating and comparing the probable requirements and related supply for future energy programs.

A modest increase in funding for University Research Support would increase funding for the University Laboratory Cooperative Program and for fuel-related support for university research reactors.

Major realignment and redirection of Energy Research Analyses occurred during fiscal year 1981. The current funding level is appropriate. In fiscal year 1982, Energy Research Analyses will conduct approximately seven technical assessments focused on specific objectives of selected programs. The impact on the capability and output of this subprogram resulting from either an increment or decrement in the budget would be proportional to the increase or decrease.

In fiscal year 1982, Multiprogram General Purpose Facilities will continue design and construction of projects started in fiscal year 1981 and begin four small, urgent projects. It is consistent with the specific objectives of the program to continue to rehabilitate and replace deficient facilities that are essential to the continued operation of the laboratories and to prolong the life of the Department's large investment in real property facilities. Additional funds would allow further work on eight of the projects, while a lower funding level would result in reduced efforts or elimination of selected projects.

Transitional Requirements

Basic Energy Sciences involves more than 2,000 scientists and engineers at DOE laboratories, at more than 150 universities, and at other sites in virtually every state. Transitional requirements would be extensive in the event that funding for the program were to be discontinued. Legislation would be required to transfer responsibility for ongoing core programs and for major facilities and laboratories to a successor organization in the Federal Government. If such a transfer were not undertaken, major national science programs would have to be abandoned.

The discontinuation requirements for the URS subprogram vary with each of its several elements. Nuclear fuel procurement requirements for university nuclear reactors are based on a 5-year operating plan. A 2-year phased transition would be necessary to complete contractual commitments.

The Energy Research Analyses and the Multiprogram General Purpose Facilities subprograms could be terminated without major legislative implications. The ERA effort is roughly 40 percent DOE staff and 60 percent contractor support. An orderly termination of the contractor support would require about a year's notice to conclude most of the committed projects. Termination of MGPF would result in significant program interruptions, reduced productivity, unsafe operations, and security risks.

(39) ENVIRONMENT AND SAFETY (EP)

Program Objectives

The Environment and Safety Program has three principal purposes: to assist departmental compliance with environment, safety, and health (ES&H) statutes and requirements; to ensure ES&H protection in all departmental operating facilities; and to secure quality assurance throughout the Department.

Cutting across departmental lines, the program is made up of two major parts: the safety subprogram and the environment subprogram. The safety subprogram encompasses nuclear safety, operational safety, and quality assurance--a range of activities involving more than 100,000 Federal and contractor employees at 159 sites. The environment subprogram is the Department's focal point for assessing environmental issues and complying with environmental legislation.

Section 103 of the Department of Energy Organization Act of 1977 (P.L. 95-91) mandates the Department "to assure incorporation of national environmental protection goals in the formulation and implementation of energy programs, and to advance the goals of restoring, protecting and enhancing environmental quality and assuring public health and safety." In addition, section 203 provides for environmental responsibilities and functions that include "advising the Secretary with respect to the conformance of the Department's activities to environmental laws and principles." Furthermore, the Department is required to conduct its operations in accordance with existing environment, safety, and health laws. Among these laws are the National Environmental Policy Act of 1969 (P.L. 91-190), as amended; the Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604); the Atomic Energy Act of 1954 (P.L. 83-703), as amended; the Toxic Substances Control Act of 1976 (P.L. 94-469); the Resource Conservation and Recovery Act of 1976 (P.L. 94-580), as amended; the Clean Water Act Amendments of 1977 (P.L. 95-217 and related legislation, P.L. 5-576, and P.L. 96-483); and the Clean Air Act Amendments of 1977 (P.L. 95-95).

The historical and current goals of the Environment and Safety Program are to provide the guidance, assistance, and overview necessary for adequate consideration of, and compliance with, environmental, safety, health, and quality assurance requirements in the Department's programs and operations. In addition, the program is intended to support remedial actions stemming from past Government nuclear operations. Tables 39-1 and 39-2 provide specific program objectives.

An administrative alternative to the guidance and overview responsibilities currently vested in the program would be to assign these functions to the line programs so that they alone would be accountable for both oversight and implementation responsibilities. This would clearly establish accountability and eliminate any potential duplication. However, the lack of an independent overview body would be undesirable for several reasons. First, an independent overview activity helps motivate the line programs to comply with ES&H requirements. Second, an independent overview program has the merit of concentrating the Department's expertise and information on ES&H issues.

Program Results

Congressional objectives have been substantially met by the Environment and Safety Program. The Department's operations have remained substantially free of accidents, public controversy, and litigation, thus assuring Congress that unresolved ES&H issues do not adversely affect the energy programs it has authorized.

The program has a direct impact on the timely implementation and execution of DOE programs by minimizing costly delays that might have resulted from noncompliance with environmental, health, and safety requirements.

During the fiscal years 1978 to 1981 period, both the safety and environment subprograms produced significant accomplishments. For example, the Department's safety record was substantially better than that of private industry in the areas of fatality and illness rates and lost workdays. A telling statistic regarding radiation exposure is that the percentage of workers in Department nuclear facilities exposed to greater than 2.0 rem has decreased steadily over the years. In 1979 only a fraction of 1 percent received greater doses. Corresponding data on nuclear facilities licensed by the Nuclear Regulatory Commission indicate an opposite trend in the 1970's, with the proportion of workers exposed to more than 2.0 rem rising to several percent by 1979.

Further details about program accomplishments as well as budget authority and obligations for the fiscal years 1978 to 1981 period are shown in Table 39-1.

Projected Program Requirements

The fiscal year 1983 budget request for the Environment and Safety Program allows continuation of selected ongoing activities, as well as improvements in nuclear safety and quality assurance standards started in fiscal years 1981 and 1982. In the safety subprogram, increased emphasis will be given to completing the initial cycle of comprehensive safety appraisals of DOE field offices started in late fiscal year 1981. The radiological emergency response capability will be continued to meet the Department's needs for its defense and nondefense nuclear operations and to maintain a national resource available to state and local agencies on request. Quality assurance and standards will focus on enhancing the Department's ability to evaluate its proficiency in all programs. Radiological surveys of former Atomic Energy Commission sites and surplus Department facilities will focus on helping to resolve the growing concerns of affected property owners.

The environment subprogram will emphasize facilitating environmental compliance by the Department's nuclear, defense, and energy research programs.

It is anticipated that during the 1984 to 1987 outyears the Environment and Safety Program will continue providing technical expertise and assistance to DOE programs in specialized environmental, safety, and health areas, as well as independent overview and assessments for the Department's senior management. Special attention will be given to nuclear safety and quality assurance. The Department's facilities, particularly those required by its national defense programs, will continue to be carefully examined. The prevention of accidents in nuclear facilities will be enhanced by improving trend analyses and by incorporating experience gained from the entire nuclear community. Current program objectives and projected program activities are shown in Table 39-2.

A 10-percent funding increase would permit the upgrading of nuclear and nonnuclear safety, quality assurance, standards, and radiological emergency response support activities, as well as accelerating the frequency of comprehensive safety appraisals of DOE field offices.

A 10-percent funding decrease would necessitate a cutback in safety and health impact analysis. Such a decrease also would delay scheduled remedial actions evaluation and certification activity and defer planned improvements in aerial measuring systems (thereby decreasing turnaround times).

Transitional Requirements

Discontinuation of funding for the Environment and Safety Program would require establishment of an effective independent overview mechanism comparable to that of the Environment and Safety Program, either elsewhere within the Department or within other Federal agencies.

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(40) HEALTH AND ENVIRONMENTAL RESEARCH (ER)

Program Objectives

The Department's Health and Environmental Research Program was established to conduct a scientifically sound and comprehensive program of research and assessment to identify, analyze, and reduce health and environmental uncertainties that impede the safe and economical implementation of domestic energy policy. A secondary goal is to conduct research and development on applying nuclear technology to the diagnosis and treatment of human diseases.

Supporting more than half the Nation's energy-related health and environmental research, the program carries out broad-based, long-term, energy-related generic research, as well as both short- and long-term research on specific energy technologies. This breadth of undertaking is important because it permits a high degree of scientific synergism whereby broadly applicable hypotheses are developed from information gathered on a number of different energy activities.

The choice of research targets is guided by many considerations, the foremost being national energy policy. The translation of energy policy into research needs is accomplished in part by identifying the sources of uncertainty underlying health and environmental issues. This permits a realistic and objective choice of the key research targets and provides a basis for comparing the potential health and environmental effects of advanced technology options and current energy alternatives. Activities include assessments of specific technologies (for example, oil shale, coal liquefaction and gasification, battery systems, photovoltaics, and the diesel engine) and generic analyses of classes of substances common to a number of energy technologies and resources (such as airborne particles).

The Atomic Energy Act of 1946 (P.L. 79-585) provided the initial charter for a comprehensive program of applied and basic biological research. This act authorizes the Department to conduct research and development related to the utilization of fissionable and radioactive materials for medical, biological, and health purposes. It also provided for the protection of health during the same research and development activities. The Atomic Energy Act of 1954 (P.L. 83-703), as amended, authorized the Atomic Energy Commission "to conduct and support research and development activities, including authority to conduct research on the biologic effects of ionizing radiation" for "the protection of health and the promotion of safety during research and production activities" and for "the preservation and enhancement of a viable environment."

The Energy Reorganization Act of 1974 (P.L. 93-438) specifically provided that the responsibilities of the Administrator of the Energy

Research and Development Administration (ERDA) shall include "engaging in and supporting environmental, biomedical, physical, and safety research related to the development of energy sources and utilization technologies."

The Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) authorized ERDA to conduct a comprehensive non-nuclear energy research, development, and demonstration program to include the environmental and social consequences of the various technologies.

The Department of Energy Organization Act of 1977 (P.L. 95-91) mandated the Department "to assure incorporation of national environmental protection goals in the formulation and implementation of energy programs, and to advance the goal of restoring, protecting, and enhancing environmental quality, and assuring public health and safety," and to conduct "a comprehensive program of research and development on the environmental effects of energy technology and programs."

During the 1977 to 1981 Title X review period, the program dealt with long-term generic research as well as a number of specific technologies and process-specific operations (for fossil, nuclear, and renewable energy resources, including conservation). Research has spanned many disciplines and areas, including biochemistry, molecular biology, genetics, toxicology, radiation biology, epidemiology, measurement sciences, and atmospheric, terrestrial, and marine sciences. Tables 40-1 and 40-2 summarize accomplishments, budget authority, and obligations for the period.

Present objectives for the Health and Environmental Research Program are similar to past objectives but with increased emphasis on long-term, mission-oriented basic research. Specifically, the program seeks to do the following:

- To identify and characterize pollutants produced from energy-related activities and to improve relevant instrumentation and measurement techniques
- To provide a fundamental understanding of the structure and function of natural and managed ecological systems to evaluate their resiliency to energy-related stress, and to understand the role of these systems in cycling and as pathways for the transmission of energy-related materials to humans
- To generate clinical and epidemiological data providing first-hand estimates of the extent of acute and late-occurring effects in humans that may result from exposure to energy-related pollutants
- To provide detailed data on laboratory health effects with molecular, cellular, and animal systems and to translate experimental information into estimates of the human health consequences of energy activities
- To support the formulation and technical management of health and environmental research programs by providing quantitative risk analyses of the interactions between energy activities, human health, and environmental quality

- To conduct a research and development program on the applications of nuclear technology to the diagnosis and treatment of human diseases

The study of the effects of the coal conversion to synthetic gaseous and liquid fuels typifies this program's research approach to an issue. Knowing the kinds of compounds or chemical species responsible for biological activity makes it possible to take corrective steps at an early stage of process development. A group of compounds with marked mutagenic and carcinogenic properties was identified, which led to the development of mitigative measures for controlling the hazard. Complementary research was undertaken on the cycling and transport of coal conversion materials through fresh water and terrestrial ecological systems, their pathway through the food chain, and the mechanisms for their uptake, metabolism, or degradation by individual organisms and populations. At the same time, another part of the program investigated synthetic fuels effluents for human mutagenicity and carcinogenicity using experimental biological systems as human surrogates to estimate susceptibility to potential harm. When this information is eventually combined with epidemiological studies from human populations engaged in these industries, it will provide a comprehensive picture of the potential health and environmental impacts of a synthetic fuel industry. Until that time, however, estimates of potential hazards to humans can be made from data obtained from experimental animal systems.

An integrated, multidisciplinary research effort also is required to resolve health and environmental issues associated with expanded use of nuclear energy. To assess the hazards of plutonium, specialized instrumentation and techniques are being developed to quantify the amounts of plutonium in process off-gases, workplace atmospheres, nuclear wastes, the natural environment, and in biological systems. Research into the environmental behavior and transport of plutonium is examining the mobility of plutonium's chemical forms in soils and sediments and its movement through the food chain leading to humans. A longstanding research program also is being conducted to document the human health effects of long-term exposure to plutonium. The results of this program have shown no increased incidence of cancer thus far in workers who accidentally received as much as six times the allowable limit of inhaled plutonium more than 30 years ago. Studies on acute and long-term effects of controlled doses of radiation from plutonium are being conducted in cultures from various species of animals and cells to define information that cannot be obtained from human exposures on the quantitative relationships between dose and incidence of cancers and mutations. Finally, projects are being sponsored to summarize the animal data and human data to make the most accurate possible estimates of risks from plutonium exposures.

The Department of Energy and its predecessor agencies have played a dominant role in developing applications of nuclear technology for use in clinical medicine and biomedical research. Examples of these activities are external imaging of dynamic organ functioning after the administration of specific radionuclides, the development of stable and radioactive isotopes for medical applications, and the radiotherapeutic use of nuclear particle accelerators. The productivity of these programs has been due to the close cooperation between DOE laboratories and university clinics and the very efficient transfer of this research information, diagnostic and therapeutic instrumentation, and methodology to the practice of nuclear medicine.

No other DOE or Federal program pursues the same comprehensive goals as the Health and Environmental Research Program. The National Institutes of Health sponsor approximately $27 million in radiation studies, primarily in support of cancer therapy. A $14-million Department of Defense program focuses on evaluating performance degradation in time periods measured from minutes to days following exposure to acute, high doses of mixed field radiation (neutron and gamma, for instance). Its purpose is to predict the ability of humans to conduct military tasks. (A program conducted by the Environmental Protection Agency (EPA) deals only with nonionizing radiation.) None of these programs characterizes the transport, fate, and behavior of radiation in the environment.

In non-nuclear areas, only EPA has attempted to address the health and environmental impacts of energy, but its program, which was funded at $45 million in fiscal year 1981, is oriented primarily to regulated pollutants associated with conventional energy resources (for example, coal combustion, diesel use, and oil spills). In contrast, the Department's Health and Environmental Research Program addresses unregulated emissions associated with the development and use of advanced fossil fuel combustion technologies, coal conversion to liquids and gas, oil shale, solar, geothermal, and fusion.

In the area of nuclear medicine, the Health and Environmental Research Program exploits the Department's capability in high energy physics and basic energy sciences to produce new, medically useful radionuclides and to synthesize new radiopharmaceuticals. It is the only focused research effort of its kind in the world.

There are various alternatives to the Health and Environmental Research Program's activities. Responsibility could be transferred to Department technology program offices. However, the multidisciplinary nature of research and analysis necessary for management of this critical program would necessitate duplication of the current health and environmental research staff in each technology program office. Generic and multitechnology research would inevitably receive less attention than process specific data needs. Such action also would preclude any independent analysis of the potential health and environmental impacts of energy technology development and commercialization.

Transfer of the program to other Federal agencies would disrupt the integrated nature of its health, ecological, and physical research components and disperse the cadre of experts and specialized facilities dedicated to resolving the uncertainties of the long-term impacts of energy activities. It would impair the close coordination of technology development and the health and environmental research and analysis demonstrated to be necessary to meet the Department's current statutory responsibilities. Moreover, the focus and intensity of program commitment would likely suffer in other agencies as it would need to compete with many other responsibilities and priorities. A transfer would thus diminish the prospect that health and environmental research data and analyses would be available in a timely manner to support the Nation's energy policy.

It is in the national interest that the relative health and environmental impacts of energy technologies be carefully investigated. Since industry is unlikely to address factors beyond those needed to demonstrate the merits of specific processes and to comply with current regulations, only the Federal Government can be expected to undertake the long-range research required. Within the Government, the Department of Energy's health, environmental, and related facilities are uniquely suited to carry out the Federal mission.

Program Results

During the past 4 years, the program attained both its own goals and objectives and those set by Congress. For example, the program defined the primary health and environmental issues and research needs for the major fossil, nuclear, and renewable resource options; developed a comprehensive and integrated multidisciplinary program of research to address these issues; and published extensive scientific information necessary for understanding and reducing the health and environmental uncertainties of major energy options.

The Health and Environmental Research Program provided nearly all of the experimental data that were employed to develop human radiation exposure standards in use throughout the world. These data served to preclude regulatory action for the substantial (and unnecessary) lowering of current occupational exposure standards. The program's radiation instrumentation research was largely responsible for state-of-the-art detection systems, while its work on radiation health protection produced most of the radiation dosimetry techniques in use today.

A widely used technique that permits very rapid screening of potential mutagenic agents evolved from genetic research on bacterial cells. This work in turn facilitates the identification of cancer-causing substances that may need to be controlled. Recently, the program expanded to become the Nation's primary experimental health effects effort for all energy-related activities.

The nuclear medicine component of the program has had a major impact on clinical medicine worldwide. It produced the technology that allows some 80 million to 100 million nuclear medicine diagnostic and therapeutic procedures to be performed yearly in the United States and developed almost all the diagnostic instrumentation now used in clinical nuclear medicine.

The concept of studying the environment as an integrated medium for the cycling and transport of pollutants was pioneered in this program and has become the basic approach for ecosystem research. An ecological monitoring design based on ecosystem dynamics was adapted by the Nuclear Regulatory Commission for routine monitoring required for nuclear plant licensing. As a result, significant savings in time and money will accrue to commercial utilities. It is estimated that for each dollar spent on environmental research under the program, more than 30 times that amount was saved in energy-related activities.

In addition to the Department and other Federal agencies, the program's beneficiaries include virtually all segments of industry, academia, and the general public. One thousand individual research projects conducted annually at 180 institutions involve more than 2,000 scientists and provide research opportunities for more than 900 graduate students and 450 postdoctoral fellows. The program has served to develop most of the Nation's radiation biologists, health physicists, radioecologists, and nuclear clinicians. The results of this research are widely disseminated. Scientists supported by the program make more than 2,500 presentations each year at technical meetings and document their work in books and in more than 3,000 peer-reviewed journal articles. The unique expertise and specialized research facilities at DOE laboratories are widely recognized and in fiscal year 1981 attracted more than $70 million from other Federal agencies and industry to conduct research in areas of mutual interest.

In the future, the Health and Environmental Research Program will concentrate more heavily on long-term generic health and environmental uncertainties as they pertain to the fossil, nuclear, and renewable energy resource technology options that will not be addressed by industry, regulatory agencies, and basic and health sciences agencies. Shorter term, process-specific research will be deemphasized.

Projected Program Requirements

In fiscal year 1982, $215.0 million was appropriated for the Health and Environmental Research Program. If sustained through 1987, this funding level would provide the following:

- Improve worker and public safety through early availability of advanced pollutant dosimetry and instrumentation systems and chemical characterization of energy effluents

- Enhance the description of atmospheric pollutant levels, from better short- and long-range transport and transformation models to improve estimates of population exposure and environmental impact

- Refine the data base to develop superior predictive models in stress ecology so that habitats can co-exist with energy expansion

- Improve generalized models for quantifying risk estimates of cancer and mutation induction following chronic low-dose exposures to gamma radiation, neutrons, and radionuclides; and continue to analyze the vital status of one-half million radiation workers and the Japanese who survived the dropping of the atomic bomb

- Develop new radionuclides for medical use and advances in the application of radiotherapy for tumor treatment

- Maintain a restricted core program of mission-oriented basic research to provide new concepts of how critical life processes respond to energy toxicants

- Update risk analyses of energy technologies to reflect new research data and to analyze the effects of pollutants common to several technologies

Reduced efforts will be necessary for assessing the health and environmental impacts of developing fossil and renewable resources, including conservation measures; for defining the transport and fate of radionuclides in the environment; and for developing biophysical instrumentation and insight into the mechanisms of biological damage.

A 10-percent increase in the support of energy-related health and environmental research would make it possible to maintain the current level of research on characterization, chemistry, and transport of toxic or carcinogenic organic compounds and of indoor air pollutants; additional region-specific environmental research; acceleration of studies of populations exposed to radiation (such as the Japanese atomic bomb survivors and populations working at nuclear installations); the more rapid development of new medical applications for isotopes, labeled compounds, and radiation beams; and maintain the health and environmental risk analysis effort.

A 10-percent decrease would result in a reduction below the fiscal year 1981 level of effort and would necessitate the termination of approximately 150 scientific staff-years.

Transitional Requirements

Termination of funding would require closing 10 dedicated laboratories and 7 major life science programs at the Department's multiprogram facilities.

Transitional funding would be required to pay termination costs; decontaminate 17 nuclear laboratories; decommission 3 reactors; transfer 10 special purpose laboratories to the universities at which they are housed; renegotiate the Radiation Effects Research Foundation Charter with Japan; transfer program commitments to other agencies; transfer information and specimen banks to other institutions; and prepare final reports summarizing research currently in progress. In addition, funds would be required to avoid the abrupt termination of research on the latent effects of ionizing radiation in laboratory animals and in worker populations. This research cannot provide useful information until some minimum time interval has passed.

4. Regulation and Information

OVERVIEW

The roots of the Department of Energy's regulatory activities can be traced at least as far back as the origins of the Federal Power Commission, which was established in 1920 to license and regulate hydroelectric power projects. Numerous statutes since then have proliferated Federal energy regulations (controlling, to differing degrees, the production, distribution, pricing, and use of most energy supplies) to achieve various, though not always compatible, policy objectives. Energy regulations have aimed to restrain consumer price increases, conserve the Nation's energy resources, stimulate development of these resources, mandate which fuels should or should not be used, and reduce energy imports.

Energy information activities go back at least to 1879, when mineral resources began to be surveyed. The Organic Act of 1910 (P. L. 61-179) authorized significant data collections in the areas of coal, petroleum, petroleum products, and other such resources. The Federal Government has provided a basic source of energy information since long before the earliest regulatory activity began in this area.

Regulation

The Department of Energy Organization Act of 1977 (P. L. 95-91) consolidated previously fragmented Federal energy regulation authorities into two agencies. The Federal Energy Regulatory Commission was created as an independent agency within the Department to regulate the national operations of public utilities. The Economic Regulatory Administration was established to administer programs affecting the pricing, allocation, and importation of oil and natural gas, as well as programs that affected the rate structure of utilities and encouraged the greater use of more abundant fuels. To minimize undue regulatory burdens resulting from departmental actions, the Office of Hearings and Appeals subsequently was set up to hear appeals from orders issued by the Department and to hear requests for adjustments from rules and regulations issued by the Department.

Some government regulation is needed to protect the health, safety, and security of the public. But regulation must be tempered with realism. Experience clearly shows that government attempts to intervene in the marketplace often produce consequences more negative than the problems that the regulatory activities were designed to overcome; and it strongly suggests that the rigidity of counterproductive, burdensome regulations is generally an inadequate substitute for the resilience of an unfettered market in which myriad knowledgeable judgments coalesce to determine the Nation's patterns of energy production and use. In this light, the Department's regulatory programs are being focused on market realities, while continuing to meet statutory obligations.

Public utilities have been subject to government regulation because of their status as natural monopolies; Federal jurisdiction over the interstate operations of utilities was established at the beginning of this century. This Federal responsibility is now carried out by the Federal Energy Regulatory Commission. More than 90 percent of the commission's activities are explicitly required by statute. Following its congressional mandates, the commission's primary goal is to regulate the national operations of electric utilities, hydroelectric powerplants, and interstate natural gas and petroleum pipelines--to ensure that industry, business, and consumers have adequate supplies of energy at just and reasonable prices, while allowing energy producers rates of return that provide sufficient incentive for increased production and efficiency.

The commission has concentrated on supporting national energy policies by building a carefully managed and streamlined agency that is able to balance competing concerns among consumers and suppliers in all areas under its jurisdiction and to fulfill its responsibilities in a timely manner. Overall, the commission's activities have resulted in public benefits that have far outweighed the costs. During fiscal year 1981, for example, the commission's total budget was only about one-twentieth of the amount of overcharges that it ordered refunded to energy consumers. Another sign of the commission's value is the fact that there has never been a dam failure at any hydroelectric power project under the commission's jurisdiction. To recover the actual costs of regulation, the commission is studying methods that will allow it to fully recover all costs associated with filings and applications. At the same time, it is working to decrease internal processing time and to reduce reporting burdens and is analyzing additional possibilities for regulatory reform.

While most of the authorities of the Federal Energy Regulatory Commission are supported by a relatively long-standing legal and political consensus, many of the programs of the Economic Regulatory Administration were designed to fulfill legislative mandates enacted during the 1970's under the pressures of energy price shocks and supply uncertainties. Some of these statutes aimed at the equitable distribution and pricing of crude oil and petroleum products, the reduction of U.S. dependence on foreign energy supplies, greater conservation efforts by electric utilities and their customers, and an increase in domestic crude oil production. Regulations were promulgated and programs were administered that provided for the location and price limitation of crude oil and petroleum products, the control and monitoring of imported crude oil, greater use of abundant fuels, the control of imported natural gas, greater fuel efficiency and rate structure revisions by utility companies. In addition, ERA created an enforcement program to ensure company compliance with existing Federal laws.

Although these were all well-intentioned programs implemented to promote the health and safety of the Nation, some failed. The petroleum allocation and price controls, for example, at times actually hampered the ability of the marketplace to respond to supply deficiencies: regional gasoline shortages were worse than they otherwise would have been; crude oil production was artificially constrained; energy efficiency was discouraged. These allocation and price controls were lifted by Executive order on January 28, 1981. In addition, many of the other programs have been discontinued as a result of the fiscal year 1982 budget process. The Economic Regulatory Administration, however, is continuing to administer those programs that are accomplishing their congressional objectives. These include the Oil Import Program, the Natural Gas Program, the Fuels Conversion Program, and a vigorous Compliance Program.

Much of the workload of the Department's Office of Hearings and Appeals testifies to the problems inherent in hastily conceived regulatory systems that place too many artificial constraints on the intricate workings of free-market forces. The office functions as an administrative safety valve and has effectively eased regulatory burdens resulting from departmental actions. Even though oil allocation and price controls, together with the related crude oil entitlements program, were ended nearly a year ago, a substantial portion of anticipated Hearings and Appeals cases over the next few years will be an outgrowth of these programs.

Following congressional intent, Hearings and Appeals has devised numerous exceptions to DOE regulations for firms or individuals who have demonstrated that they would suffer a serious financial hardship in the absence of exception relief, that an exception would foster national energy policy objectives, or that a regulatory requirement was unfair. Since its predecessor was created in 1974, Hearings and Appeals has issued more than 49,000 decisions and orders in cases involving exceptions, administrative appeals of orders issued by DOE program offices, contested factual or legal issues in enforcement matters, special refund procedures for distributing funds obtained by the Department in enforcement cases, and special redress relief for persons or firms who otherwise have no administrative recourse.

The adjudicatory processes administered by Hearings and Appeals have been instrumental in easing regulatory burdens to permit market forces to operate to the maximum extent possible within the petroleum industry. For example, through the exceptions process the office has approved relief for small and independent refiners to foster competition in the refining sector of the petroleum industry. During the 1979 gasoline shortage, the office expeditiously increased allocations of gasoline for thousands of small retailers, municipal police departments, and health service organizations by granting exceptions from DOE regulations.

Information

If one of the functions of the Office of Hearings and Appeals is to serve as a corrective for the negative side effects of regulatory remedies, then it could be said that the Energy Information Administration (EIA) is an important part of the national program for helping to maintain the health of energy markets. As a second independent agency within the Department of Energy, EIA was created to consolidate dispersed energy information authorities into one program. EIA collects, validates, analyzes, and disseminates energy information needed for statistical, congressional, regulatory, and other purposes. Reliable information about the energy picture--past, current, and projected--is essential to the Nation if it is to keep its balance as it negotiates its way to a secure energy future.

No matter what the regulatory environment, as long as there is some Government or private concern over the Nation's energy future, it will be necessary to maintain a program that provides relevant, accurate, and objective information for decision-makers--whether they be government officials, industry executives, or homeowners--to make informed decisions. Credible, timely information is vital to the effective working of both regulated and unregulated markets. It is required to monitor and judge the performance and results of any plan for determining the Nation's energy supply, distribution, and consumption patterns, and it is required to plan intelligently for future needs.

The Energy Information Administration fills the need for a Federal Government entity having central, comprehensive energy data collection and analysis authority. EIA has developed and maintains a credible energy information base which can be used by the executive branch, Congress, state governments, industry, and the general public in making informed decisions. Many EIA publications are generally recognized, both inside and outside the energy industry, as among the most authoritative sources of energy information.

EIA also provides energy data, analysis, and information processing support to other Department of Energy offices, including support to departmental contingency planning and emergency operations for use in preparing for and coping with supply disruptions. Further, EIA prepares energy analyses and projections on a regularly scheduled basis as well as for special purposes. To comply with the intent of Congress expressed in the enacting statute, EIA continues to "assure and maximize the independence of the data collection and analysis functions within the Department." And it continues to ensure that there are sufficient data and analyses to meet statutory requirements and to meet the needs of the decision-makers, while minimizing the reporting burden on businesses and individuals.

(41) ECONOMIC REGULATORY ADMINISTRATION (RG)

Program Objectives

The Economic Regulatory Administration (ERA) was established by the Department of Energy Organization Act of 1977 (P.L. 95-91) to carry out many of the previously scattered regulatory programs involving energy supply systems for petroleum, natural gas, coal, and electricity.

Among the major legislation requiring regulation of these energy industries are the Emergency Petroleum Allocation Act of 1973 (P.L. 93-159), the Natural Gas Act of 1938 (P.L. 75-690), the Natural Gas Policy Act of 1978 (P.L. 95-621), the Powerplant and Industrial Fuel Use Act of 1978 (P.L. 95-620), the Public Utility Regulatory Policies Act of 1978 (P.L. 95-617), the Energy Conservation and Production Act of 1976 (P.L. 94-385), and the Trade Expansion Act of 1962 (P.L. 87-794). Most of the authorities contained within these statutes are still current; some, such as those within the Emergency Petroleum Allocation Act, have expired.

To carry out these and other legislative mandates, ERA formulated and administered a variety of regulatory and nonregulatory programs. Under the authorities of the Emergency Petroleum Allocation Act, the Department of Energy was responsible for ensuring the equitable pricing and distribution of crude oil and petroleum products. To accomplish this objective, ERA promulgated regulations that controlled crude oil prices and designed various allocation systems. ERA also designed and administered programs that provided for greater financial incentives to increase production of crude oil from high-risk drilling ventures; it worked with state regulatory agencies and public utilities to bring about rate structure changes that would foster greater conservation of electricity; and it carried out a program to encourage the use of coal and other more abundant fuels. A more detailed description of each program objective can be found in Table 41-1.

As can be seen in Table 41-2, ERA now is administering only a few of its original programs. Included among them are the Mandatory Oil Import Program, which authorizes and monitors crude oil and petroleum product imports; the Natural Gas Program, which authorizes natural gas imports and exports and participates in Federal Energy Regulatory Commission proceedings to facilitate orderly transition to a deregulated natural gas market; and the Fuels Conversion Program. In addition, ERA is continuing a vigorous Compliance Program to complete enforcement activities for violations that occurred during the period of the allocation and price controls. Other programs have been phased out as a result of the fiscal year 1982 budget process.

The functions currently carried out by ERA could be transferred logically to other Federal agencies. For example, the Mandatory Oil Import Program could be administered by the Department of Commerce, which is responsible for reviewing all proposals to export petroleum and petroleum products and which could monitor and control crude oil and product imports as well. It is likewise feasible that the Department of Commerce and/or the Federal Energy Regulatory Commission could administer programs related to imports and exports of natural gas. With respect to the Compliance Program, once the audit phase is completed and cases are in litigable form, the enforcement litigation activities could be carried out by the Department of Justice.

Program Results

As can be seen in Table 41-1, during fiscal years 1978 through 1981, ERA gradually shifted its emphasis away from regulating the oil industry. Many petroleum products were decontrolled, and plans were made for the orderly phaseout of all remaining crude oil and product controls by September 30, 1981. However, on January 28, 1981, all crude oil and petroleum product controls were lifted by Executive order. Thus, ERA's focus changed dramatically from administering crude oil programs to formulating regulations to eliminate them.

The primary reason for these changes has been the recognition that the free market is a far better regulator of supply, price, and demand than the Federal Government. While most regulations were promulgated in an effort to correct market inequities, experience has shown that they often resulted in other market anomalies. For example, the oil allocation and pricing regulations, which ERA designed to ensure the equitable pricing and distribution of crude oil and product supplies to all energy consumers, at times seriously hampered the ability of the marketplace to respond to short-term problems and actually led to regional supply shortages. Thus, while these regulations served to remedy one inequity, they caused others. They were exceedingly complex, confusing, and inflexible. It became clear that no allocation system can accurately reflect recent growth or decline in demand among areas or among firms and individuals. They cannot anticipate nor accurately adjust for shifts in demand caused by supply uncertainty or the effects of higher oil prices.

The pricing regulations, which attempted to insulate consumers from rising petroleum prices, hampered conservation, encouraged imports, discouraged domestic production, and generally stifled competition throughout the domestic energy industry. There is even some basis for believing that U.S. consumers now are paying petroleum product prices that are higher than they otherwise would have been had price controls never been imposed.

Some of ERA's programs, however, have successfully contributed to the Nation's overall energy goals and have accomplished the intent of Congress. For example, the Mandatory Oil Import Program continues to provide a vital data system for monitoring all imports of crude oil and petroleum products; the Natural Gas Program has ensured the equitable pricing of imported natural gas products and thus preserves the viability of our domestic market; and the Compliance Program has successfully recouped millions of dollars from companies that violated the allocation and pricing regulations and has returned money to harmed parties. All these programs have benefited the Nation as a whole and have helped stabilize the country's energy environment.

Projected Program Requirements

The appropriation for fiscal year 1982 is $47.2 million. Funding and staffing will be directed toward the Compliance Program, activities administered under the Oil and Gas Operations Program, and the Fuels Conversion Program.

The Compliance Program will continue enforcement actions for noncompliance within the provisions of the Emergency Petroleum Allocation Act, while working toward an orderly phaseout of audit activity. The objective of the program for fiscal year 1982 and beyond is to resolve, either by settlement or by litigation, all remaining alleged violations. By accomplishing these objectives, the Compliance Program will fulfill the Administration's commitment to identify and continue to collect overcharges for injured customers or for the U.S. Treasury in cases where injured parties cannot be readily identified.

The fiscal year 1982 resource level for the ERA Compliance Program is the amount necessary to pursue all identified violations. This resource level is consistent with the Department's announced intention to pursue all outstanding violation cases and not to grant general amnesty for violations during the period of controls. An additional 10 percent in funding would provide added assurance that the fiscal year 1982 inventory of compliance cases will be pursued to resolution. Conversely, a 10-percent reduction in resources would hamper the planned effort for an orderly phaseout of the Compliance Program.

The Mandatory Oil Import Program will continue under the authority of the Trade Expansion Act and Presidential Proclamation No. 3279. During fiscal year 1982, a licensing mechanism will continue to be applied to all imports of crude oil, finished petroleum products, and unfinished oils. Import transactions of all petroleum transmitted by the Bureau of Customs will be entered into the Oil Import System under appropriate licenses. An oil import fee licensing system including bonding and surety requirements will be maintained so that a mechanism will be in place in the event oil import fees are reimposed in the future.

During fiscal year 1982, there will be continuation of applications review for import and export licensing of natural gas (including liquefied natural gas) under the Natural Gas Program. The need for future imported natural gas supplies in various regions of the United States will be analyzed, including analyses of the impact on domestic production. By authorizing imports and exports of natural gas, where appropriate, adequate supplies of natural gas will be ensured to supplement domestic supplies at reasonable prices that will not dampen domestic production. Minimizing the regulatory burden and facilitating the efficient use and distribution of natural gas supplies will maximize development and production of natural gas.

A 10-percent increase in the fiscal year 1982 resource level for the Oil and Gas Operations Program would help eliminate the lag time in processing oil import and natural gas import/export applications resulting in an enhanced governmental capability to assess the volumes of such transactions.

Conversely, if the Oil and Gas Operations Program were required to effect a 10-percent reduction from the fiscal year 1982 resource level, the reduction in staff would cause greater lag times in processing oil import and natural gas import/export applications.

The Fuels Conversion Program in fiscal year 1982 will continue to facilitate utility conversion to coal, issue exemptions to the Powerplant and Industrial Fuel Use Act, and remove and approve annual utility conservation plans. However, no continuation of the Fuels Conversion Program is being projected in fiscal year 1983 on the assumption that the Clean Air Act will be amended during the 97th Congress such that voluntary coal conversions are accorded equivalent treatment as federally mandated conversions and on the assumption that the Fuel Use Act will be repealed. If this does not occur, the Fuels Conversion Program will continue.

Transitional Requirements

Lack of funding would terminate performance by ERA of its responsibilities with respect to gas imports and exports, gas curtailment policy, compliance with the Emergency Petroleum Allocation Act, and fuels conversion. Some of these functions would need to be performed by a transferee or successor agency to avoid termination being unduly disruptive. Interaction between the Fuels Conversion Program and the Clean Air Act, discussed above, should be considered in any termination of funding for the Fuels Conversion Program.

(42) HEARINGS AND APPEALS (HG)

Program Objectives

The Office of Hearings and Appeals (OHA) is responsible for all the Department of Energy's adjudicatory processes, other than those administered by the Federal Energy Regulatory Commission or the Board of Contract Appeals. This office therefore reviews and decides applications for exception submitted by individual firms or persons who believe that a DOE-issued rule, regulation, or order causes a serious hardship, gross inequity, or an unfair distribution of burdens. OHA is also responsible for deciding final administrative appeals in adjudicatory matters under the jurisdiction of the Secretary of Energy and for providing an adjudicatory forum in enforcement matters to consider contested issues of fact or law prior to the issuance of remedial orders.

OHA's jurisdiction derives from the Secretary's delegations of authority under several different statutes. The Department of Energy Organization Act of 1977 (P.L. 95-91) requires the Secretary to entertain requests for adjustments to any rule, regulation, or order issued by the agency from any person affected by the operation of its programs. Many of these rules, regulations, and orders are based in legislation. For example, the Department of Energy Organization Act established the Energy Information Administration within DOE and gave it the authority to require firms to report statistical information concerning U.S. energy resources. The act also transferred to DOE the Federal Energy Administration's responsibility for administering the Mandatory Petroleum Allocation and Pricing Program that had been adopted pursuant to the Economic Stabilization Act of 1970 (P.L. 92-8), the Energy Conservation and Production Act of 1976 (P.L. 94-385), the Federal Energy Administration Act of 1974 (P.L. 93-275), and the Emergency Petroleum Allocation Act of 1973 (P.L. 93-159). Title III of the National Energy Conservation Policy Act of 1979 (P.L. 95-619), the Emergency Energy Conservation Act of 1979 (P.L. 96-102), and the Energy Policy and Conservation Act of 1975 (P.L. 94-163) require DOE to establish various energy conservation programs. Adjustments on a case-by-case basis to rules issued by all these programs may be made.

OHA also exercises the functions of the Office of Private Grievances and Redress, which is required by the Federal Energy Administration Act, and issues determinations on petitions for special redress. Finally, the following statutory and executive authorities require that DOE provide a forum for administrative appeals of orders: the Freedom of Information Act of 1974 (P.L. 93-502); the Right of Privacy Act of 1974 (P.L. 93-579); DOE Notice DOE N 4510.1, "Policies for Acquiring Commercial or Industrial Products and Services Needed by the Government" (based upon Office of Management and Budget Circular A-76); and 10 C.F.R., section 218.32(d), which provides for OHA review of Presidential supply orders issued pursuant to the International Energy Program, TIAS No. 8278.

The historical objective of the Office of Hearings and Appeals has been to ensure the lawful and equitable operations of DOE regulatory programs by expeditiously resolving petitions for regulatory relief and by providing an adjudicatory forum for resolving disputes of fact and law in enforcement proceedings. This goal has remained constant throughout fiscal years 1978 through 1981. The current goal of OHA is to concentrate staff efforts on completing all exception and enforcement matters associated with the mandatory petroleum price and allocation regulations. (That goal will be more fully discussed in the Projected Program Requirements section in this PAU.) As the data in Tables 42-1 and 42-2 and the Program Results section indicate, the priorities assigned to particular functions have been adjusted periodically to attain OHA's objective.

The exceptions process provides a mechanism for adjustments in cases where the application of a DOE regulation, ruling, or generally applicable requirement in a particular case produces a serious hardship, gross inequity, or an unfair distribution of burdens. In such a case, OHA considers the financial and operating position of the applicant and whether the situation may frustrate important national policy goals if relief is not granted. The appellate function provides a forum for the timely and equitable resolution of administrative appeals from orders and notices issued by DOE. Through its appellate decisions, OHA has corrected numerous factual and legal errors which otherwise would have led to time-consuming, costly, and probably unsuccessful Federal court litigation. Historically, OHA has considered appeals from actions taken under the Freedom of Information Act and the Privacy Act. The actions taken by the Economic Regulatory Administration under the Mandatory Petroleum Allocation and Pricing Program have produced the bulk of the appeals received by OHA.

The Economic Regulatory Administration conducts audits to establish compliance with petroleum allocation and pricing regulations. Where a violation is found to have occurred, enforcement proceedings leading to the issuance of a proposed remedial order may follow. OHA provides an administrative forum in which the violations alleged in these proposed remedial orders may be contested and reviewed. OHA proceedings permit firms to contest the Department's preliminary findings of fact and law prior to the issuance of a final remedial order. The special refund process permits the Department to consider and formulate plans for distributing funds obtained through enforcement actions in cases where affected parties are not readily identifiable or where the extent of damage incurred is not readily ascertainable. Funds also may be distributed to the U.S. Treasury.

Through petitions for special redress, OHA also provides a review forum within the Department for aggrieved parties who have no other form of administrative redress.

As noted in Table 42-2, alternative methods of achieving OHA's objective consist either of shifting adjudicatory responsibilities to other agencies or to DOE's Office of the Secretary, or of abandoning some types of adjudications. A transfer of responsibility for OHA's remaining complex caseload to another governmental entity without a concomitant transfer of OHA personnel would frustrate the objective of providing speedy resolution of these matters.

Program Results

The degree to which the Office of Hearings and Appeals' objectives have been achieved is best analyzed by an examination of its processing of different types of cases. A quantitative review of OHA's yearly caseload and the annual cost of the program is contained in Tables 42-1 and 42-2. The qualitative results are discussed below by type of case.

Exceptions. During fiscal year 1978, a large portion of the exception requests processed by OHA concerned crude oil producers who claimed that they would have no incentive either to continue operations or to make major capital investments on their crude oil-producing properties because of the economic constraints imposed by the price control regulations. OHA developed standards for approving exception relief to such firms so that crude oil would be extracted from properties that otherwise would have been abandoned. More than 500 of these cases have been resolved during the history of this program.

During fiscal years 1979 and 1980, the caseload of OHA dramatically increased as a result of the shortages of crude oil and motor gasoline that occurred in the United States after the revolution in Iran. From March 1, 1979, to February 28, 1980, OHA received approximately 24,000 petitions for relief from the motor gasoline allocation regulations. In those applications, most of which were filed by small retail service stations, applicants alleged that their gasoline allocations were inadequate to sustain profitable operations. Other firms contended that their communities were suffering acute shortages of fuel. Police departments and other emergency and health-service organizations also sought additional supplies during that period. Where applicants were able to substantiate their claims, OHA promptly issued orders granting increased allocations of gasoline.

OHA also received 287 applications during fiscal year 1980 from firms that wished to produce or market gasohol. Where a firm demonstrated that it was in an advantageous position to further the national objective of reducing U.S. reliance on imported crude oil but was prevented from entering the gasohol market because of the DOE allocation and price regulations, the firm was granted exception relief that provided it with an assured supply of gasoline to enable it to market gasohol.

During fiscal year 1981, the emphasis has been on exception cases involving different aspects of the complex Domestic Crude Oil Entitlements Program. To facilitate the orderly conclusion of the Entitlements Program, OHA most recently has been processing these cases on a priority basis.

Remedial Orders and Special Refund Procedures. During fiscal years 1978 through 1980, the majority of the remedial order cases processed by OHA concerned small firms that produced crude oil or resold petroleum products such as gasoline. In the course of determining whether final remedial orders should be issued in those cases, OHA has provided a body of case law that is widely used by regulated firms in interpreting the DOE regulations. During fiscal year 1981, the type of remedial order proceeding changed, and a substantial number of those proceedings now pending before OHA present extremely complex issues of fact and law involving major refiners and allegations of multimillion dollar violations. Most legal observers believe that the final resolution of these complex remedial order proceedings will take several years of litigation before OHA, the Federal Energy Regulatory Commission, and the Federal courts.

Petitions for the implementation of special refund procedures can be filed by the Economic Regulatory Administration's enforcement offices in cases where it is difficult to identify the persons who should receive refunds for overcharges or in cases where the amount of those refunds is not readily ascertainable. Very few petitions had been filed or acted upon before fiscal year 1981. However, the removal of price controls by Executive order on January 28, 1981, has had two significant effects: many more firms have entered into settlements with DOE, and the price control system no longer provides a ready mechanism for distributing overcharges to those who were injured by them in the past. As a result, OHA now has received a substantial number of these petitions and has issued many determinations setting forth procedures for the distribution of consent order funds to individual and institutional claimants.

Petitions for Special Redress. As these cases may only be filed when other administrative procedures are inapplicable, it is difficult to categorize their effect on the public. One important example of this type of case is Consumer Federation of America, 1 DOE, paragraph 82,556 (1978), in which the Deputy Secretary directed OHA to consider the Consumer Federation of America's request for limited financial assistance to participate in a controversial public hearing concerning the prices of home heating oil.

Appeals. OHA's timely processing of Freedom of Information and other appeals cases is detailed in Table 42-1. The analyses set forth in the decisions issued by OHA provide useful guidance to the Department's program offices. In addition, the appellate process serves as an effective and cost-efficient means of correcting errors made during the initial stages of administrative processes.

In addition to the objective of providing an adjudicative forum for DOE, Congress has repeatedly indicated its desire that OHA should expeditiously process all cases according to easily ascertainable standards so that the exceptions process would be accessible to firms of all sizes. To this end, OHA has issued a series of guidelines setting forth the standards for exception relief and explaining the types of evidence necessary to substantiate an application for exception. Members of Congress have frequently praised OHA for the quality of its work and for the speedy resolution of its voluminous caseload.

Projected Program Requirements

As indicated in Table 42-2, a substantial number of cases will remain to be completed after OHA's projected completion of 2,040 cases in fiscal year 1982. A completion date for all cases cannot be predicted at this time because many of the cases that will be filed must be initiated by participants in the Entitlements Program, which has been the subject of extensive litigation. In addition, the Economic Regulatory Administration's predictions of enforcement and refund cases it will file with OHA have varied with its proposed levels of funding.

Although the President exempted all crude oil and petroleum products from the Mandatory Petroleum Allocation and Pricing Program on January 28, 1981, OHA is continuing to process appeals, exceptions, enforcement actions, and special refund proceedings generated by the program during the 8-year period when controls were in effect. Many of the remaining cases are extremely complex and will require at least 1 to 2 years simply to complete the preliminary procedural stages.

In fiscal year 1982, the enacted budget of OHA is $4.8 million. Since the majority of the costs associated with OHA are personnel costs, an increase or decrease in funding levels would result in an increase or decrease in personnel and a corresponding proportionate change in the number of cases processed and in the average case age. At the enacted level of funding for fiscal year 1982, OHA anticipates that it will resolve 2,040 cases per year. At a level of funding reduced by 10 percent, OHA would be able to resolve only 1,850 cases. At a level of funding 10-percent higher, 2,260 cases would be resolved per year. Even at an enhanced level of funding, OHA's closing inventory of cases for fiscal year 1983 could be as high as 5,790 petitions remaining to be resolved in fiscal years 1984 through 1987.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. Discontinuation of OHA's program activities without a final adjudication of the pending cases could cloud the financial and legal status of firms that were the subject of uncompleted enforcement and exception proceedings. As a result, the Federal Government might become embroiled in more major energy litigation if it dropped the administrative exceptions and appeals process. However, the Department would employ its existing authorities to minimize disruption associated with program termination.

(43) FEDERAL ENERGY REGULATORY COMMISSION (FC)

Program Objectives

The Federal Energy Regulatory Commission (FERC) is an independent regulatory agency within the Department of Energy. FERC regulates the sale and transmission of natural gas, establishes rates for wholesale sales and the interstate transmission of electric power, licenses non-Federal hydroelectric power projects, and regulates rates charged by pipeline companies to transport crude oil and petroleum products in interstate commerce. The commission also has the authority to review certain rulemakings and major energy actions proposed by the Secretary of Energy.

The statutes that govern the commission's responsibilities in these areas have evolved over 80 years as part of Congress' desire to monitor and regulate those energy generation, transmission, and distribution industries that it considered to be relatively noncompetitive natural monopolies. As the electric utility and oil and gas pipeline industries have grown, FERC's statutory responsibilities have been expanded to ensure that consumers receive energy at just and reasonable prices while, at the same time, allowing suppliers a fair rate of return.

FERC traces its institutional origin to the former Federal Power Commission, which was established by Congress in 1920 to license and regulate hydroelectric power projects built and operated by private firms, states, municipalities, and other non-Federal entities. These duties were expanded by the Federal Power Act of 1935 (P.L. 74-333), which extended the Federal Power Commission's authority to the interstate operations of electric utilities, and by the Natural Gas Act of 1938 (P.L. 75-690), which gave it similar responsibilities over interstate natural gas pipelines.

The Department of Energy Organization Act of 1977 (P.L. 95-91) transferred to FERC most of the responsibilities of the Federal Power Commission as well as certain energy regulatory functions from other agencies. The act also directs FERC to review certain rulemakings proposed by the Secretary of Energy and selected final oil pricing and allocation decisions made by DOE. FERC's regulatory responsibilities were sharply expanded in November 1978 by the Natural Gas Policy Act of 1978 (P.L. 95-621) and the Public Utility Regulatory Policies Act of 1978 (P.L. 95-617). These two portions of the National Energy Act considerably broadened the scope of the commission's programs and added significantly to its administrative and enforcement workload.

FERC exercises its statutory responsibilities through 86 specific regulatory processes which are condensed under four major categories: gas regulation, hydropower regulation, oil regulation, and electric regulation. Accomplishments and budgetary costs for these four program areas are presented in Table 43-1.

FERC's primary goal continues to be the regulation of the national operations of public utilities to ensure that energy users have adequate supplies at just and reasonable prices while energy suppliers are allowed rates of return that provide sufficient incentive for increased production and efficiency. Within that overall context, the commission's current goals are to reduce the pending workload in all the regulatory processes under its jurisdiction; reduce the burden of regulation on industry through an ambitious program of updating, simplifying, and revising existing FERC rules; give priority to critical energy projects and cases; and process the significant growth in hydroelectric applications, the dam safety inspections program, and the oil pipeline regulation activities. Specific program goals are shown in Table 43-2.

While the commission's regulatory responsibilities have expanded tremendously, especially since the passage of the National Energy Act in 1978, industry and citizens alike continue to express increasing concern that many Government regulations are excessively burdensome, fail to protect the public's broader interests, or, in some cases, are no longer appropriate in view of changing economic conditions. In an effort to respond to these concerns, the commission has initiated a detailed review of the statutes governing its activities to identify opportunities for reform.

Program Results

Energy regulation in the public interest requires a careful balancing of competing concerns. In all areas under its jurisdiction, the commission has constantly striven to achieve a rational balance between the needs of energy users and the needs of energy suppliers.

During FERC's first 3 years of existence, the public benefits of energy regulation have far outweighed its costs. One such benefit is provided in the form of refunds to consumers by those regulated industries determined by the commission to have charged rates in excess of just and reasonable levels. Refunds in fiscal year 1980 were more than $1 billion, and in fiscal year 1981 they were $1.4 billion. It is estimated that $1 billion in refunds will be ordered during fiscal year 1982.

To reduce the burden on industries under its jurisdiction, the commission has devoted considerable effort to eliminating unnecessary reporting requirements. Since October 1979, it has reduced reporting burdens by 570,000 hours per year, or almost 275 workyears. The commission plans to expand this program, with the goal of reducing both applicant filing burden and internal processing time.

While the total workload of the commission has more than doubled since fiscal year 1978 (mainly as a result of new responsibilities mandated by the Natural Gas Policy Act and Public Utility Regulatory Policies Act), pending workload actually has been reduced by more than 11 percent during the same period. Commission productivity continues to rise in the face of dramatic increases in the number of new cases. The commission received or initiated 77,111 actions during fiscal year 1980. During the same period, it completed action on 77,819 items, resulting in a 5-percent reduction in pending workload.

The commission also seeks to preserve environmental quality at project sites by including protective measures in its licensing orders. Licenses issued by the commission contain conditions for protection of fish and wildlife, water quality, historical and archeological sites, and scenic and cultural values. They also provide for recreational opportunities, flood control, and the efficient and safe operation of project dams.

A major FERC responsibility in hydropower regulation is to ensure the safety of the projects under its jurisdiction. The commission has authority over more hydroelectric dams than the Corps of Engineers, the Bureau of Reclamation, and the Tennessee Valley Authority, collectively. Considering the health and safety consequences of a dam failure, the dam safety inspection program is an extremely important part of FERC's hydropower regulation effort. There has never been a dam failure at any site under FERC jurisdiction.

Projected Program Requirements

The current program objectives are summarized in Table 43-2. The enacted budget authority for fiscal year 1982 is $76.2 million, including an October 1981 pay raise adjustment. As the new workload under the National Energy Act comes under control, personnel are being moved from the natural gas programs to assist with the rapidly expanding workload in the hydropower licensing and electric-power regulation areas.

The commission's budget request for fiscal year 1983 includes funds to relocate and centralize commission operations in one location--and thereby increase the efficiency of these operations. Excluding the relocation funds, the budget request represents the commission's continuing effort to eliminate the backlog of casework created by the Natural Gas Policy Act and the Public Utility Regulatory Policies Act and to respond to the mandates of both acts as well as to pressures resulting from renewed interest in hydroelectric development. The budget request will provide for the completion of nearly 55,000 workload items. Pending workload will be reduced by 21 percent to 9,249 items--a reduction of 2,420 items from fiscal year 1982.

At a 10-percent decrease in funding, the major FERC objective to bring all workload current by the end of fiscal year 1985 would be delayed at least to the end of fiscal year 1987. In the gas regulation area, workload output would decrease significantly, thereby reducing or delaying supplies of natural gas. A total of 1,852 workload items would not be completed. Activities related to industrial and feedstock curtailment filings would be compromised, as would any analysis of the natural gas supply and demand situation. Time required to review environmental and safety aspects of pipeline certificates and curtailment filings would increase. Rate reviews would be performed only on major cases, with all other cases receiving cursory review. Delays in the investigation, enforcement, or other dispositions of pipeline rate cases would result in consumers being forced to pay rates that ultimately may be found to be unjust and unreasonable.

In the hydropower licensing area, a 10-percent decrease in funding would lead to less frequent inspection of those operating dams that have the least potential for downstream loss of life and property. Construction inspections would be reduced from the desired monthly inspections to nine inspections per year on complex developments, six inspections per year on moderately complex developments, and three per year on less complex developments.

A 10-percent funding reduction in oil regulation would result in a decrease of 74 workload items. Specifically, formal tariff filings would suffer a 7-percent loss in completions. In addition, the program objective to initially audit all pipeline carriers and pipeline systems within a minimum of 7 years would slip to a 9-year period. Finally, the timetable for completion of Phase II hearings of the Trans Alaska Pipeline System case would not be met.

In the area of electric regulation, the objective to bring all workload current by the end of fiscal year 1985 would not be met and would probably be delayed until fiscal year 1987. Workload activity would focus on docketed items; a total of 1,130 filings and audits would be completed. Refunds of excessive rates totaling between $10 million and $20 million would not be processed.

A 10-percent increase in FERC's budget would mean that the commission could accelerate the reduction of its overall pending workload, could ensure that all analyses and investigations could be performed expeditiously without compromising quality, and could further streamline the agency to increase productivity.

Transitional Requirements

More than 90 percent of FERC's activities, explicitly mandated by statute, involve oversight of energy production, transportation, and sales. The remaining 10 percent involve FERC management efforts to do its job more efficiently and effectively. Therefore, changes to the commission's statutory base would be required to transfer the commission's mandated responsibilities to prevent undue disruption from lack of funding.

(44) ENERGY INFORMATION (EI)

Program Objectives

The Energy Information Administration (EIA) was created as an integral yet independent entity within the Department of Energy. The mission of EIA is to serve as an independent, central, and comprehensive source of energy information. EIA also collects and processes related economic statistical information and data relevant to the adequacy of energy resources to meet demands in the near and longer term for the Nation's social and economic needs. A credible and consistent base of energy information is necessary to the executive branch, Congress, state governments, industry, and the general public, so that those who make decisions about energy in all sectors of our society have the tools to make those decisions well.

The legislative history of the Department of Energy Organization Act of 1977 (P.L. 95-91) reflects the intent of Congress to create, for its own use as well as the use of the executive branch and the public, a statistical and analytical office which, while being close to the decision-makers, would be separated from the policy-formulation functions of the Department. The conference report written to accompany the act states: "It is the intent of the conferees, by the establishment of this Energy Information Administration, to eliminate duplication and overlap now existing in energy information programs. It is also the conferees' intent to assure and maximize the independence of the data collection and analysis functions within the Department."

The EIA program is based squarely in this law. Prior to the passage of the DOE Organization Act, a diverse set of authorities existed for similar purposes. While energy information activities go back at least to 1879 (when mineral resources began to be surveyed) and to the Bureau of Mines Organic Act of 1910 (P.L. 61-179) (authorizing data collections for coal, petroleum, and other such resources), specific energy information authorities were provided in the Federal Energy Administration Act of 1974 (P.L. 93-275), which authorized the FEA Administrator to "collect, assemble, evaluate and analyze energy information." Following closely on the heels of the FEA Act, the Energy Supply and Environmental Coordination Act of 1974 (P.L. 93-319) provided the FEA Administrator the authority to "request, acquire, and collect such energy information . . . necessary to assist in the formulation of energy policy" or to carry out the purposes of the act. Other specific authorities were provided by the Energy Conservation and Production Act of 1979 (P.L. 94-385) and the Emergency Energy Conservation Act of 1979 (P.L. 96-102). Moreover, the Department depends on EIA's data and analysis to carry out its statutory mandates provided in at least seven other public laws: P.L. 75-688, the Energy Policy and Conservation Act of 1975 (P.L. 94-163), the Natural Gas Policy Act of 1978 (P.L. 95-621), the Powerplant and Industrial Fuel Use Act of 1978 (P.L. 95-620), the National Energy Conservation Policy Act of 1978 (P.L. 95-619), the Energy Security Act of 1980 (P.L. 96-294), and 16 USC 791a et seq. Under the Department of

Energy Organization Act, the EIA Administrator must exercise independent judgment in fulfilling the agency's mission and is directly accountable for the cost and the quality of EIA data and analysis. The Administrator is not required to obtain the approval of anyone else in the Department regarding the collection or analysis of any information or the approval of any other Federal official or employee with respect to the substance of any statistical or forecasting technical report prepared in accordance with law. The purpose behind this level of independence, according to Congress, is to permit EIA to function in a totally objective way in addressing questions raised in the national energy debate.

The integral but independent character of EIA as a data and analysis office within the executive branch is unique in the Federal structure. This characteristic carries with it a potential for conflicting views from different parts of the Department. To ensure an open environment in such a situation, an essential feature of EIA's operation is full, free, and early consultation between EIA and the policy and program areas of the Department <u>before</u> publication of data and analysis--not to limit, but to inform both EIA and the rest of the Department. EIA has operated in this manner from the beginning.

EIA's historical goal remains its current goal: to carry out an independent, central, comprehensive, and unified energy data information program to collect, evaluate, assemble, analyze, and disseminate data and information relevant to energy resource reserves, energy production, demand and technology, and related economic statistical information, or which is relevant to the adequacy of energy resources to meet demands in the near and long term for the Nation's economic and social needs. For a more detailed discussion of program objectives, and the degree to which EIA has accomplished these objectives, see Table 44-1.

Within the context of the existing legislative requirements, there are no means for achieving these objectives outside the operation of EIA or an EIA-like organization. Alternatives for the provision of energy information and analysis include: dependence on the private sector or state governments; development by agencies requiring the information; and centralization in another Federal agency. However, energy industry trade associations provide information unique to their area of interest, and states only for their geographical location. Neither of these sources could assure the consistency, objectivity, or credibility already extant in EIA. Furthermore, the Federal Government could not be assured of receiving information on matters of national concern where these matters might differ from industry and state priorities. Decentralizing energy information throughout the Federal Government could conceivably provide all the information that was needed, but at far greater costs of administration, coordination, duplication, and reporting burden. Also, there would be no assurance that information and statistical series were comparable or consistent. In all cases, analysis would be more difficult because the expertise would be scattered or unfocused. Economies and improvements might be effected in other respects, as in sharing resources for research in statistical methods, access to restricted data, or sharing universe lists and consolidating sample surveys. However, the extent of such cost savings and benefits is highly uncertain and is not likely to fully offset the potential for cost increases associated with decentralization. None of these alternatives would fulfill the current legislative requirements.

EIA conceivably could be shifted intact into a different location in the Government and continue performing as it currently does essentially within the context of current law. Depending on where responsibilities were located for regulatory functions and the energy policy role of the Federal Government, some coordination problems might arise, but they would be much less than they would be if the information function itself were scattered. In fact, were other energy functions decentralized, the centralization of energy information would be even more crucial to provide the necessary focus for effective management of the energy information function in the Federal Government.

Interestingly, trade associations use EIA data as the standard, or baseline, from which they do their own analyses. In fact, most of the basic oil, gas, coal, and electricity information has been collected by the Federal Government, in some cases for more than 100 years. State agencies in some cases collect consumption information in the form of tax revenue data, as for motor gasoline. However, neither the disparate Federal and state agencies nor the various trade groups--all of which have gathered limited data to satisfy their particular immediate purposes--have been able to provide a comprehensive view or consistent treatment of the total energy picture; and the trade associations are not obligated by law to be objective. Indeed, the diversity of definitions and biases placed on energy data by the representative trade groups in part led to the creation of EIA.

Program Results

Over its 4-year history, EIA has maintained its role as the Federal Government's primary source of comprehensive energy information. EIA seeks to provide relevant information for whatever national program exists, be it free market, regulatory, or somewhere in between. This goal has been achieved within the bounds of the expectations that were assigned to EIA at the time of its creation.

The first of these expectations is objectivity. This has been met by attending to the fundamentals of designing only those necessary surveys that ask the right questions of the right people; by sound sampling procedures; by well-documented data bases and computer models; by systematic internal and external review of products; and by comprehensive, effective dissemination activities. This also has been achieved by building an in-house staff with the proper skills and institutional memory.

The second principal expectation is that EIA would provide data and analytical support to all parts of the Department, the executive branch, and Congress. This has been achieved by the recognition of EIA as the Department's independent source of analyses and a source of verifiable energy statistics in the Federal Government. As noted in Table 44-1, over the 4 years it has existed, EIA has responded to more than 160,000 data inquiries and has distributed nearly 10 million copies of its publications. The requests have come from other executive branch agencies, Congress, industry, trade associations, and the general public. This expectation has also been met because of an acceptance that EIA will be completely open in its efforts to contribute neutral, objective, and competent information. It must be noted that a portion of the EIA budget is devoted to supporting the programs of other Department entities. By law, EIA provides the energy data support needed for DOE offices to carry out their missions, be they operational or regulatory. Congress also has shared in the recognition of EIA's service. During previous sessions of Congress, EIA was called upon by the Senate Committee on Energy and Natural Resources to give periodic briefings on the current and expected energy situation. During the last congressional session, EIA was the first Department witness to appear before this same committee for hearings on an assessment of the national and international energy picture.

The third principal expectation is that EIA would serve the public by making credible information readily available. In 1977 and 1978 there were numerous sets of energy statistics; and there was much disagreement over which, if any, of the numbers were "right." During earlier congressional hearings on energy issues, the accuracy and objectivity of energy data were often questioned. For example, the sources of petroleum and natural gas reserve data were the American Petroleum Institute and the American Gas Association, both of which had a vested interest in the potential outcome of the debate. This question of bias tainted the debate at various times. Today, that picture has changed significantly. EIA's data are accepted as the standard. Debate during the past year has focused, as it should, on policy, not data accuracy. In addition, access has been enhanced through the generation of significant tools to aid users in locating and using EIA data and analyses.

The fourth notable expectation is that EIA, in performing its data collection efforts, impose as little respondent burden as possible. This has been accomplished by an initial review of the data collection forms inherited from predecessor agencies as well as by the institution of an annual review of data collection forms and the preparation of an information collection budget geared toward reducing respondent burden. In fact, the Office of Management and Budget has cited EIA as a model for burden control and forms clearance. EIA will continue its efforts toward this end, particularly in light of the Paperwork Reduction Act of 1980 (P.L. 96-511).

To improve operational efficiency, EIA was reorganized during 1981. This streamlining has helped EIA focus its attention on basic energy statistics and relevant analysis. As a result, the Financial Reporting System, certain aspects of consumption data, and other information programs have been carefully reviewed. It was determined that they impose an excessive level of burden in return for the minimal additions they make to existing data. As the Nation moves from a regulated energy marketplace to a free-market approach, there will be more limited need for these types of information. In an environment of less Government intervention in the marketplace, coupled with the need for reduced Government spending, it is necessary to cut programs with the lowest marginal utility. However, EIA will continue to collect basic energy information, while retaining the capability to collect additional information should the need arise, such as might occur during a severe energy emergency.

An excellent measure of how well EIA has met the objectives of Congress [illegible] been provided by the Professional Audit Review Team. Congress created [illegible] team, pursuant to the Energy Conservation and Production Act, to review and report annually on the energy data collection and analysis activities of the Office of Energy Information and Analysis of the Federal Energy Administration, EIA's predecessor. Although in earlier reports EIA was criticized for different reasons, it has more recently received high marks for its achievement of the primary objectives set forth by Congress. These reports also review the overall performance of EIA programs in achieving its nonstatutory yet implied program objectives.*

Since its inception, EIA has developed and maintained a comprehensive, integrated, and detailed information system. This system was acknowledged as an integral tool for decision-makers in the public and private sectors. Achieving this goal has not been an easy task. It has required a great deal of introspection and revision in response to congressional and other external critical review. Even so, the costs of this function have totaled less than 1 percent of the cost of all energy programs over this same period. As a result, EIA was able to define clearly its objectives and readily pinpoint the activities necessary to successfully achieve these objectives.

Projected Program Requirements

In the face of the needs to reduce Government spending and intervention, and of reduced regulatory requirements for detailed energy information, EIA has made significant changes in the way it operates. EIA activities for fiscal years 1981 and 1982 already have been substantially reoriented to eliminate burdensome, detailed data collections and overrefined analyses, while retaining the capability to provide meaningful, timely, and accurate energy information. Proposed legislation to help accomplish this reorientation, the Energy Information Administration Amendments of 1981, was submitted to the Congress and introduced in the Senate (S. 1281) in May 1981. Table 44-2 contains additional detail concerning fiscal year 1982 program requirements.

Commencing with fiscal year 1983 and continuing for the next 5 fiscal years, the preferred course is for EIA to maintain a stable operation. The projected 5-year funding level for fiscal years 1983 through 1987 will allow EIA to provide the basic energy information necessary for decision-makers, both public and private. The proposed funding level for fiscal year 1983 reflects a reduction in the scale and frequency of some data collections, a reduction in quality assessment activities, and the elimination of longer term projections and analysis of energy trends. An objective Government source of longer term projections currently is required by law. However, in light of the current availability of such information from private sector sources, the inherent uncertainty that attaches to any longer term projections, and the need to reduce government spending, legislation will be proposed to eliminate this requirement. A 10-percent increase in funding would permit continuation of this capability, although scaled down. A reduction of budgetary resources below fiscal year 1983 target levels would significantly diminish EIA's ability to carry out its programs in the manner prescribed in its basic legislative mandate.

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*See Activities of the Energy Information Administration: Report to the President and the Congress, December 1977; May 7, 1979; November 13, 1980.

Transitional Requirements

The central requirement for program discontinuation is that Congress determine whether and in what fashion the information and analyses programs of EIA continue. As long as the statutory mandate for a central, comprehensive source of energy information exists, there will be a need for an EIA-like organization somewhere in the executive branch.

5. Energy Production and Power Marketing

OVERVIEW The Department of Energy inherited responsibility for three major programs that produce and distribute energy: the Naval Petroleum and Oil Shale Reserves; uranium enrichment activities; and the power marketing administrations. In all three cases, there is a continuity between current and historical program goals.

The Naval Petroleum and Oil Shale Reserves were established primarily as an emergency petroleum source for the military, a function expanded by the Naval Petroleum Reserves Production Act of 1976 (P.L. 94-258), which called for the reserves to provide "essential defense, industrial, and military emergency energy requirements relative to the national safety, welfare, and economy, resulting from foreign military or economic action." Recently, President Reagan determined that it is in the national interest to continue production of the Naval Petroleum Reserves at their maximum efficient rates until April 4, 1985.

The Uranium Enrichment Program has served the uranium requirements of domestic and foreign utilities as well as the U.S. Government. Program objectives continue to be the fulfilling of contracts for uranium enrichment as economically as possible; the expanding of DOE's enrichment capacity to meet increased demand; and the building of additional plant capacity while protecting the environment and guarding public health and safety.

The five power administrations--Bonneville, Alaska, Southeastern, Southwestern, and Western Area--sell electricity generated at Federal multipurpose water projects by the U.S. Army Corps of Engineers or the Department of the Interior's Bureau of Reclamation. First priority for sale of this low-cost power generally is accorded to public bodies and cooperatives; this is known in the industry as "preference." Power is priced at the lowest rate consistent with recovery of the cost of production and sound business practice, and rates are uniform throughout each system. Earned revenue affects annual operations and maintenance costs, repays the capital investment, and pays the interest on the unpaid capital invested in power.

(45) NAVAL PETROLEUM AND OIL SHALE RESERVES (EP)

Program Objectives

The Naval Petroleum and Oil Shale Reserves (NPOSR) were created between 1912 and 1924 by Executive order. NPOSR consists of three petroleum reserves (two in California and one in Wyoming) and three oil shale reserves (two in Colorado and one in Utah). The petroleum reserves are estimated to contain more than 1 billion barrels of recoverable hydrocarbons. Their original purpose was to provide liquid hydrocarbon fuels to the armed forces during wars and other emergencies. Except for a short period during World War II, the reserves remained untapped until the disruption in world oil markets in 1973-74 led to the decision to explore the reserves and develop them to their full productive capacity.

The petroleum reserves now are being produced at their maximum efficient rate. At its peak, this rate is approximately 180,000 barrels of oil per day. All revenues from sales go to the U.S. Treasury.

The bulk of the hydrocarbons are produced from the Naval Petroleum Reserve No. 1 (NPR-1) at Elk Hills, California (175,000 barrels of oil per day, 320 million cubic feet of natural gas per day, and 600,000 gallons of natural gas liquids per day). The production of Naval Petroleum Reserve No. 3 (NPR-3) at Teapot Dome, Wyoming, is significantly lower (3,500 barrels of oil per day, 8 million cubic feet of natural gas per day, and 17,000 gallons of natural gas liquids per day). Less than 300 barrels of oil per day are received by the U.S. Government as royalty oil from Naval Petroleum Reserve No. 2 (NPR-2) at Buena Vista, California.

NPR-1 is owned jointly by Chevron U.S.A. and the Government, with the Government's share being about 80 percent; NPR-2 consists of a number of parcels, some owned by the Government and some by various private firms; and NPR-3 is wholly owned by the Government. NPR-1 and NPR-3 are developed and produced under contract with unit operators: Williams Brothers Engineering Company at NPR-1 and Lawrence-Allison, West, at NPR-3. All the oilproducing lands owned by the Government are leased. The oil shale reserves have not been developed or produced, although a predevelopment plan is almost completed.

Development of the petroleum reserves to their full potential called for a substantial number of wells to be drilled at NPR-1 and NPR-3 and for construction of new facilities valued at more than $400 million. The predevelopment program started for the oil shale reserves consists primarily of environmental and resource assessments.

The basic authority to explore, develop, and produce NPOSR is contained in Title 10 of the United States Code, Chapter 641. This statute directs the Secretary to explore and develop the reserves and authorizes him to assess them at any time. Current production at the maximum efficient rate was mandated by the Naval Petroleum Reserves Production Act of 1976 (P.L. 94-258) through April 4, 1982. The act provides for extension of such production for 3 years, and the President has found that continued production is in the national interest. The petroleum reserves also are affected by the Energy Security Act of 1980 (P.L. 96-294), which authorizes the sale of Naval Petroleum Reserve petroleum to the Department of Defense and mandates that NPR-1 be shut in if the fill rate for the Strategic Petroleum Reserve (SPR) drops below 100,000 barrels of oil per day until it contains 500 million barrels. Congressional oversight for NPOSR is provided by the House and Senate Armed Services Committees.

Since passage of the Naval Petroleum Reserves Production Act, the goal of the NPOSR Program has been to continue development and production activities to recover petroleum at the maximum efficient rate. The Secretary of Energy has agreed that the Government's share of such production will be made available for purchase by the Department of Defense after April 4, 1982. Predevelopment activities related to Naval Oil Shale Reserve No. 1 (NOSR-1) in Colorado are to be completed during fiscal year 1982, and the feasibility of leasing Naval Oil Shale Reserve No. 2 (NOSR-2) in Utah for oil and gas development, along with analysis of options for development, is to be evaluated. Tables 45-1 and 45-2 summarize specific historical and current objectives for NPOSR, program accomplishments, and budget information.

There are no other Government programs with identical objectives. The Department of the Interior's leasing program involves oil and gas production for certain Federal lands; however, the management of those lands differs from the management of the NPOSR since they were not originally linked to the interests of the Nation's armed forces. The Strategic Petroleum Reserve Program is aimed at storing oil for emergencies and is a more efficient means for providing for emergencies than the NPOSR. Under existing legislation, there are no viable alternatives to achieve NPOSR's goals.

Program Results

As national needs have changed, so, too, have the requirements levied on NPOSR. At first, reserve petroleum was sold competitively to the highest bidder. In 1980, it was decided that 100,000 barrels of oil per day from NPR-1 should be exchanged for oil to fill the Strategic Petroleum Reserve. (At the time, SPR filling had been discontinued for about a year.) Later, the Defense Department's request was accepted for the purchase of some petroleum beginning on July 1, 1981, and for all Government oil produced from the petroleum reserves after April 4, 1982. The oil shale reserves predevelopment plan was reduced in scope to include only NOSR-1. Although it should be completed on schedule in 1982, there are no follow-on plans to begin NOSR-1 development in the near term; however, development options are being evaluated. Evaluation of seismic testing activities has commenced at NOSR-2 and could lead to its being leased for oil and gas production by fiscal year 1984.

The national and local impacts of the program have been and continue to be highly positive. Between October 1977 and the end of September 1981, petroleum production totaled approximately 220 million barrels, yielding more than $4.6 billion to the U.S. Treasury. This production significantly reduced import needs, the balance-of-payments deficit, and the Federal budget deficit. At the same time, the program helped to meet some of the Nation's highest priority objectives--to fill the Strategic Petroleum Reserve and to provide a secure petroleum supply for the armed services. By virtue of its high-quality oil feedstock, NPR-1 production has provided significant support to the California refining industry. Between 1,500 and 2,000 civilian jobs have been created in California and Wyoming as a result of reserve activities.

Continued petroleum production at the maximum efficient rate after April 4, 1982, should result in additional economic benefits. For example, it is projected that in fiscal year 1982 production from the reserves will average 175,000 barrels of oil per day, yielding nearly $2 billion to the U.S. Treasury.

All program activities during the period were carried out in accordance with national, state, and local regulations. There were no adverse impacts on the environment, on health, or on safety.

The program also met congressional objectives. For example, it was the intent of Congress to develop the petroleum reserves to their full potential, an intent substantially attained through the program's exploratory and drilling activities and through construction of petroleum processing facilities. The petroleum reserves were produced at their maximum efficient rate pursuant to the Naval Petroleum Reserves Production Act. Specific program accomplishments for fiscal years 1978 through 1981 are detailed in Table 45-1. During this period, production at NPR-1 increased from 119,138 barrels of oil per day in fiscal year 1978 to an average of 171,400 barrels of oil per day in fiscal year 1981. Meanwhile, revenues rose from $0.5 billion to $1.6 billion. Production at NPR-3 peaked at 5,115 barrels of oil per day in fiscal year 1979, declining to 3,378 barrels of oil per day in fiscal year 1981.

During the same 4-year period, 28 exploratory and 594 development wells were drilled at the two reserves. Waterflood projects were initiated at NPR-1, and a pilot enhanced oil recovery project was started at NPR-3. Additional gas processing facilities were constructed at NPR-1 and NPR-3 to handle the increasing volume of natural gas production.

Predevelopment plans for NOSR-1 are scheduled to be completed in fiscal year 1982, yielding a programmatic environmental impact statement and a full assessment of the oil shale and hydrological resources at the Colorado site. The seismic test program at NOSR-2 also is scheduled for completion during the same year. It seeks to improve current estimates of the reserve's oil and gas potential.

<u>Projected Program Requirements</u>

The fiscal year 1982 budget for NPOSR is $213.1 million. This provides for continuing recovery of petroleum at the maximum efficient rate (which will average about 175,000 barrels of oil per day in fiscal year 1982); the drilling of 119 development wells and 4 exploratory wells; continuing enhanced oil recovery tests at NPR-3; and completing the predevelopment plan for NOSR-1. The fiscal year 1983 budget request also assumes continued production of the petroleum reserves at their maximum efficient rate (which for fiscal year 1983 will average about 160,000 barrels of oil per day). For that year, 106 development wells and continued exploratory work are planned. Minor modifications to facilities are scheduled to maintain production at the maximum efficient rate. The request also provides funding for completion of the pilot phase of the NPR-3 enhanced oil recovery program. Total receipts at the requested level are estimated to remain at the fiscal year 1982 amount as a result of higher petroleum prices. Nominal funding is being requested for the oil shale reserves to provide for continued maintenance and to conduct limited monitoring of changes in climate, air quality, and ground water elevations.

Assuming that the petroleum reserves will continue to produce at their maximum efficient rate, estimated revenues will be $9.2 billion for the fiscal year 1985 to 1989 period. The bulk of the outyear expenditures would be to operate the petroleum reserves and drill an additional 270 development wells and 11 exploratory wells. In addition, should pilot tests prove favorable, plans call for the design and development of full-scale enhanced oil recovery projects at NPR-3 (to commence in fiscal year 1984). The oil shale reserves will remain in a maintenance state, pending policy decisions on development options.

Additional funding of 10 percent would accelerate the drilling program. Because of the inherent characteristics of oil field reservoirs, however, that would not necessarily be desirable. To continue development of the field in a prudent manner while producing at the maximum efficient rate requires the study of new geologic data from each new well before subsequent wells are drilled in that reservoir. Similarly, a 10-percent decrease in funding would reduce the drilling program (by roughly one well per $1 million decrease). This, in turn, could reduce ultimate recovery by not permitting full drainage of all reservoirs. In addition, it would not make sense inasmuch as reserves from the new development wells cover the drilling costs in less than 90 days, and fewer wells would result in reduced production and sales receipts. Table 45-2 provides additional details about projected program activities.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(46) URANIUM ENRICHMENT ACTIVITIES (NE)

The fundamental goal of the Government's uranium enrichment activities has remained relatively constant for many years. It is to meet domestic, foreign, and U.S. Government requirements for uranium enrichment services in the most economical, reliable, safe, and environmentally acceptable manner possible. The program is authorized by the Atomic Energy Act of 1954 (P.L. 83-703), as amended. Section 161(v) authorizes the Department of Energy to enter into contracts to enrich normal uranium owned by foreign and domestic operators of nuclear power reactors.

The Department of Energy currently enriches uranium to the desired assay of the isotope uranium-235 (U-235) in its gaseous diffusion plants at Oak Ridge, Tennessee; Portsmouth, Ohio; and Paducah, Kentucky. These plants were built in the 1940's and 1950's and were operated initially to satisfy defense requirements for U-235. Now they are operated primarily to provide enrichment services to domestic and non-U.S. utility customers to fuel nuclear powerplants. In its plants, DOE enriches customer-provided natural uranium in the U-235 component for a fee that recovers the full cost of providing the services.

Although the bulk of production is for commercial sales, the enrichment plants are essential for several Government programs. Enriched uranium fuel for naval reactors is supplied from the plants, as are all enrichment services needed for nuclear weapons production. The fuel for research reactors operated by DOE and for several reactors operated by foreign governments under various international agreements also is supplied from the plants.

A potentially viable alternative to Government ownership and operation of the uranium enrichment facilities would be to sell the enterprise to private industry, or otherwise stimulate the creation of private enrichers. This alternative currently is being given consideration by the Department.

Program Objectives

The increasing demand for enrichment services requires the continued design and construction of the Gas Centrifuge Enrichment Plant at Portsmouth, Ohio. The plant will provide an additional 2.2 million separative work units (SWU's) of capacity by 1989, and it can be completed by sequentially adding capacity in blocks as dictated by demand. The original capacity of the plant was designed to be 8.8 million SWU's (see Table 46-1); however, as a result of recent success in the development program of advanced centrifuge machines which can be installed in later modules, the current total capacity is now 13.2 million SWU's and can be achieved at no additional cost or impact on schedule.

To improve efficiency, reduce costs, and maintain the U.S. position as the dominant enrichment services supplier in the world, the Department of Energy conducts a research and development program on advanced methods for enriching uranium. This includes research on advanced gas centrifuge (AGC) machines--the first of which will be 50 percent more efficient than the current models--and on advanced isotope separation (AIS) technologies.

AIS processes employ lasers or radio waves to separate the desired isotope, U-235. The three AIS processes being pursued are the Atomic Vapor Laser Isotope Separation Process, the Molecular Laser Isotope Separation Process, and the Plasma Separation Process. The Department's contractors for the AIS program currently are completing construction of the prototype test beds, as discussed in Table 46-1. These subsystems will begin operation at the beginning of calendar year 1982 and will operate for a minimum of 3 months before a single process is chosen for full-scale engineering development.

The Department's charges for uranium enrichment services are intended to recover the Government's full costs over a reasonable period of time, in accordance with Section 161(v) of the Atomic Energy Act of 1954, as amended, and with the Uranium Enrichment Services Criteria. The cost of providing enrichment services includes electric power supplied to the enrichment plants, direct and indirect labor needed to operate the plants, process development, DOE administration, depreciation of plant and equipment, and imputed interest on the Government's investment in uranium enrichment. As a result, the commercial portion of the enrichment enterprise is fully reimbursed by utility customers at no cost to the taxpayer. Appropriated funds are required for services provided to Government users (that is, national defense or research). Appropriated funds also may be required during major construction projects such as the Gas Centrifuge Enrichment Plant, when current revenues are insufficient to meet the temporarily heavy investment. In such cases, the appropriations are repaid through the depreciation charge.

The program's specific current objectives are directed to production operations and to improved production capability (see Table 46-2). Those pertaining to production operations are as follows (specific performance within each element can be seen in Table 46-1):

- To produce, at minimum cost, enriched uranium in quantities that meet projected demand

- To recover all Government costs over a reasonable period of time

- To keep the plant on stream 99 percent of the time

- To prevent the erosion of DOE's current share of the enriched uranium market and capture new market opportunities

The objectives associated with improving production capabilities are as follows:

- To complete diffusion plant cascade improvement and uprating programs by the third quarter of fiscal year 1983 within the cost goal of $1.5 billion

- To design and construct a gas centrifuge enrichment plant that will provide an additional 13.2 million SWU's of capacity by 1994 (2.2 million in 1989)

- To develop advanced isotope separation and advanced gas centrifuge technologies that produce enriched uranium at a cost less than any present production cost. (For AIS, the intention is to choose a technology for scaleup in April 1982, complete preprototype testing by 1984, and develop an engineering development module by 1989, while the AGC objective is to develop by 1988 Set IV machines whose performance is 50 percent better than current machines.)

Program Results

The original goal has remained relatively unchanged, and the program has done quite well in achieving its successive objectives. Production, costs, revenues, and onstream plant time have been very close to targets. The projects for major production improvement and capacity expansion have moved ahead on schedule and within budget. Nevertheless, the U.S. share of the world enrichment market has dropped alarmingly. As a result of increased foreign competition, declining demand for nuclear power, and export policies based on fears of nuclear weapons proliferation, the U.S. share of the foreign market declined from 72 percent in 1978 to 29 percent in 1981.

DOE's uranium enrichment activities continue to benefit the Nation as a whole, both in the commercial and in the national defense sectors. Commercial sales provide the fuel for all nuclear power reactors in the United States and for many foreign reactors. Power reactors provide an energy alternative to imported oil, both for the United States and for many of our allies. Sales to foreign customers, which totaled $388 million in fiscal year 1981, also favorably affect the U.S. balance of payments.

The enrichment program provides jobs for approximately 11,000 contractor employees who operate the plants for the Department, and it promotes general economic stability by maintaining control of this energy source within the United States. This is accomplished at no cost to the taxpayer, given that enrichment services are priced to recover the Government's cost over a reasonable period of time.

As noted above, production of enriched uranium is essential for national defense purposes. The program provides the enriched uranium for finished nuclear weapons, fuel elements for naval reactors, and fuel elements for land-based power and research reactors. Currently, naval reactor fuel represents essentially the total Department of Defense requirement for newly produced enriched uranium.

The Department of Energy's enrichment plants operate as commercial facilities and must comply with local, state, and Federal regulations pertaining to the environment, health, and safety. The gas centrifuge is especially attractive environmentally because it will use only 5 percent of the electric power used to operate a diffusion plant of similar throughput. Besides freeing electrical capacity to satisfy other needs, this reduces the total amount of primary fuel consumed and the pollutants of all types emitted.

One objective of Congress in passing the Atomic Energy Act of 1954 was to establish a viable nuclear energy industry. DOE's uranium enrichment activities have supported this objective by producing 100 percent of the enriched uranium fuel for the domestic reactors that today produce 11 percent of all U.S. electricity, along with fuel for many foreign reactors and all enriched uranium requirements for our national defense.

Projected Program Requirements

U.S. uranium enrichment activities will be needed as presently contracted demand dictates. Contracts have been signed by the Department of Energy to deliver enrichment services to utility customers beyond the year 2000. Construction of the Gas Centrifuge Enrichment Plant must continue in order to meet the demand of 31 million SWU's per year estimated by the mid-1990's (compared with 9.6 million SWU's in 1981) and to provide a low-cost production capability that is significantly less affected by electricity rates than is the present gaseous diffusion technology. Research on advanced isotope separation and advanced gas centrifuge enrichment must continue also, to reduce production costs further and to improve the U.S. position vis-a-vis foreign enrichment competitors. The production for commercial sales and Government needs will be close to self-financing for the next 5 years, with Government needs funded through the users' appropriations and cost of commercial sales returned through revenues received. Annual appropriations of $30 million to $50 million per year may be needed over the next 5 years to meet costs associated with capital projects that cannot be recovered until a later date.

The enrichment plants are being operated currently at the lowest level possible to balance long-term supply and demand. A permanent 10-percent reduction in the current program funding level would result ultimately in breach of contract with existing customers. Even a near-term reduction of 10 percent in production operation would risk permanent damage and degraded performance to the production equipment, since they are already being operated at minimum levels.

A 10-percent reduction in the Gas Centrifuge Enrichment Plant would further delay the project, raise the total cost of construction, provide insufficient capacity to meet demand in the 1990's, and postpone economic benefits accruing from this more energy-efficient, lower cost technology. In research and development on AIS and AGC, a reduction would also delay economic benefits, especially from the next generation of AGC machines, which are scheduled to be introduced in operations in 1989.

A 10-percent program increase would be applied primarily to accelerated construction of the Gas Centrifuge Enrichment Plant and to research on AIS and AGC. This would speed up the economic benefits expected from them.

Transitional Requirements

Discontinued funding would have the following effects: major production and research facilities in four states, with an acquisition cost of $4.2 billion, would have to be shut down and mothballed or sold; 11,000 contractor employees would be terminated; 296 commercial supply contracts for services, valued at $100 billion, would have to be terminated; alternative supply sources to meet national defense needs would have to be arranged; and alternative sources of fuel would have to be found for all operating or planned nuclear reactors.

The only possible alternative to Government operation of the enrichment plants would be to sell them to the private sector. As previously mentioned, this proposal is under active consideration by the Administration.

(47) POWER MARKETING (CE)

Program Objectives

The five power marketing administrations are responsible for marketing the power produced at all Federal multipurpose water projects, except for the Tennessee Valley Authority. The five are the Alaska Power Administration, established in 1967; the Bonneville Power Administration, established in 1937; the Southeastern Power Administration, established in 1950; the Southwestern Power Administration, established in 1943; and the Western Area Power Administration, established in 1977.

The Federal Government began in the early 1900's to conserve, develop, and manage the water resources of the United States on a river basin basis. This policy was implemented initially through the Corps of Engineers in the Department of the Army and the Bureau of Reclamation in the Department of the Interior. Those agencies were authorized to construct and operate multipurpose water projects in the various river basins to provide domestic and industrial water supplies, irrigation, navigation, flood control, recreation, fish and wildlife habitat, pollution and salinity control, and hydroelectric power.

In 1906, the Secretary of the Interior was authorized to market hydroelectric power from Federal reclamation projects. The Secretary was further authorized in the 1930's to construct and operate transmission lines to market power and in the Flood Control Act of 1944 (P.L. 78-534) to market all power produced at Corps of Engineers projects. Beginning in 1937, with the establishment of the Bonneville Power Administration, power marketing was assigned to separate regional power administrations. In 1977, Congress transferred to the Department of Energy the four existing power marketing administrations--Alaska, Bonneville, Southeastern, and Southwestern--and also the Bureau of Reclamation's power marketing function, which became the Western Area Power Administration.

Although more than 100 statutes now govern the power marketing program, three of these lay the foundation for the present activities of the five power administrations: the Bonneville Project Act of 1937 (P.L. 75-329); the Reclamation Project Act of 1939 (P.L. 76-260); and the Flood Control Act of 1944. Additional legislation within the last decade has expanded the role of the Bonneville Power Administration. The Federal Columbia River Transmission System Act of 1974 (P.L. 93-454) authorized Bonneville to integrate generation from all sources within the region and to place its revenues in a revolving fund and expend them for purposes necessary in performing its duties. The act also authorized Bonneville to borrow up to $1.25 billion through the issuance of revenue bonds. The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) authorized Bonneville to acquire power from non-Federal sources to meet the requirements of its customers which exceeded the capability to meet their needs prior to the enactment of the act. Priority in resource acquisition must be given to cost-effective conservation measures and renewable energy resources. The act also obliges Bonneville to protect, mitigate damage to, and enhance the fish and wildlife resources of the Columbia River and its tributaries. Finally, the act sets forth a formula whereby the residential customers of privately owned utilities may be allocated a portion of Bonneville preference power.

The power administrations now report directly to DOE's Assistant Secretary for Conservation and Renewable Energy. Their work is coordinated by the Office of Power Marketing Coordination, which also serves as a central staff to the Assistant Secretary and as the Washington liaison office of the Alaska, Southeastern, and Southwestern Power Administrations. The Assistant Secretary provides overall policy guidance and supervision to the five administrations and the Office of Power Marketing Coordination; the administrators are responsible for the day-to-day management of their administrations. Except for Bonneville, the Assistant Secretary also establishes rates on an interim basis and refers them to the Federal Energy Regulatory Commission for confirmation and approval on a final basis.

Federal hydroelectric power is priced to recover all costs of producing and marketing the power, including recovering the capital invested, with interest, over a reasonable time period, not to exceed 50 years. Interest usually is determined at the start of construction and is based on the average yield on long-term Treasury bonds. Revenues annually recover the operation and maintenance costs of the Corps of Engineers and the Bureau of Reclamation as well as each power administration, the costs of any power purchased to make the available hydropower marketable, the costs of wheeling service provided by other utilities, interest on the unamortized capital debt, and a portion of the capital invested in power and in irrigation features beyond the ability of the water users to repay. Bonneville, being self-financed, uses its revenues directly to pay annual costs and to return capital invested with interest to the Treasury. The other power administrations deposit their revenues in the Treasury and obtain appropriations from Congress to operate and maintain their systems, purchase power and wheeling, and undertake needed capital investments for transmission construction and rehabilitation.

All five power marketing administrations have the following primary goals (see Table 47-1):

- Market all hydropower available from Federal dams
- Market all power at the lowest possible rates consistent with sound business principles to recover the costs of operation and capital invested in power with interest
- Repay reimbursable capital investment within a reasonable period, usually 50 years
- Give preference in the sale of power to public bodies and cooperatives
- Construct and operate transmission lines with a high degree of system reliability

- Market power at uniform rates to encourage the most widespread use of electricity

Some additional goals apply to only one power administration. The Alaska Power Administration has the objective of operating and maintaining the Eklutna and Snettisham generating stations, and of investigating potential renewable electric power resources in Alaska. Bonneville's distinct goals are to acquire electric energy resources, through conservation and other acquisitions, sufficient to meet the Administrator's obligations to regional utilities; to develop technology in high-voltage transmission; and to protect, enhance, and mitigate damage to fish and wildlife resources of the Columbia River and its tributaries.

The power marketing functions are not duplicated by any other Federal program. Alternatives to the present system are limited by the complex relationships of the power marketing program to the diverse objectives of the Federal water resources management programs. Power will continue to be generated and transmitted from Federal dams in accordance with legislated multipurpose project objectives. The question is what institutional alternatives are reasonable for marketing the power in a manner that serves the interests of the consuming public while ensuring recovery of the Government's investment and costs of delivery.

Among these alternatives is the creation of regional entities (private, public, or quasi-public), composed of both consumer- and investor-owned utilities, to market the power and repay the Federal investment. This alternative might require a large capital investment to buy out the Federal interest, and it would require a major legislative change.

Another alternative is the creation of a Government corporation to administer the power marketing program. It could have a board of directors drawn from the regions served and could be self-financed from the revenues generated by rates charged. This would require major legislation, and it might or might not require a large capital investment.

The long-established principles of the power marketing program also could be preserved by retaining the existing Federal power marketing administrations. The program could remain with other energy functions, be returned to the Department of the Interior, or be housed in a new Federal agency established for this purpose. The five power administrations and the central staff with its legal support could be transferred intact and operate immediately. Because the power marketing program recovers through rates all of its costs of operation, such changes also could be associated with placing the entire program on a self-financed basis.

Program Results

The goals of the power administrations are ongoing, rather than fixed in time, and are pursued continuously. All objectives, except those assigned to Bonneville by the Pacific Northwest Electric Power Planning and Conservation Act and now being implemented, are regularly met. The power administrations are virtually operating utilities, and the marketing of power from 122 Federal water projects is a continuing process. All the hydropower available has been sold, most of it under long-term contracts which expire at various dates between now and the year 2004. As additional capacity and energy are made available from new projects or from additions at existing ones, it is promptly allocated and sold. The demand for Federal hydropower far exceeds the supply.

In fiscal year 1980, the power administrations sold 123.3 billion kilowatt-hours, about 45 percent of the Nation's hydropower production, or 6 percent of total electricity production. They operate and maintain over 30,000 miles of transmission lines and related facilities such as switch-yards, substations, and power dispatch centers. The five power administrations serve a total of 886 wholesale customers, of which 365 are municipal electric utilities; 209 are rural electric cooperatives; 203 are other Federal, state, and county agencies, including public utility districts; 65 are irrigation districts, industries, and other users; and 44 are investor-owned utilities.

In the Pacific Northwest, where hydropower provides 80 percent of the electricity, the Federal hydro system meets half the region's electricity needs and all the electricity needs of many preference customers. Bonneville also provides 80 percent of the region's high voltage transmission. The Alaska Power Administration is the principal power supplier to Juneau and a major supplier to Anchorage and adjoining communities. Throughout the other western states, the Western Area Power Administration provides the majority of its preference customers with firm power at a relatively high load factor. Southeastern and Southwestern sell most of their power for peaking purposes and supply only about 10 percent of the needs of their customers. Wherever it is sold, however, Federal hydropower provides a valuable renewable energy resource which is especially useful for peaking purposes and which permits the conservation of oil, gas, and other nonrenewable fuels used in the production of electricity.

The Federal power program has had a major impact upon the economies of the regions that it serves. The Pacific Northwest, which had been limited primarily to an extractive economy based upon lumbering, mining, and farming before the 1930's, has developed a balanced industrial base, including an aluminum industry which produces one-third of the Nation's aluminum supply and a major aircraft production industry. Low-cost hydropower has encouraged the development of other related industries. In the Missouri and Colorado basins, in California, and in the Pacific Northwest, Federal water and power development have assisted the development of irrigated agriculture and have contributed to economic growth.

Over the years the Federal power marketing administrations have maintained high operating efficiency and system reliability. All the administrations have an excellent safety record, have kept outages to a minimum, and, when outages have occurred, have restored service promptly and efficiently. In cooperation with DOE's Office of Electric Energy Systems, Bonneville has developed extra-high-voltage transmission technology and in the Pacific Northwest has demonstrated the benefits of an efficient regional transmission grid.

Another measure of operating program success concerns the allocation and marketing of power. All allocations and all rate adjustments are based upon substantial public involvement and participation. The administrations maintain close contact with customers and with organizations of customers on both a regional and national basis.

One assessment of the program is the adequacy of the revenues to recover the costs of operation and to repay invested capital with interest. Since the program began, Congress has invested $11.4 billion in the power features of water resources projects and an additional $1.4 billion in the irrigation features which power users are expected to repay. Of this $12.8 billion, more than one-third has been invested since 1975. Through fiscal year 1980, the five power administrations had collected $10.8 billion in revenues. Those funds were used to repay $3.3 billion in operating expenses by the generating agencies and the power administrations; $1.5 billion for the purchase of power and wheeling; and $3.2 billion was returned to the Treasury for interest on the unamortized balance of the debt. The remainder, $2 billion, was applied to repay the capital investment, leaving $10.8 billion remaining to be repaid. (Preference in the sale of power to public bodies and cooperatives, as required by law, has had no bearing on the ability of the power administrations to repay their fiscal obligations.)

Before 1978, rate adjustments had been relatively rare and small for all the administrations. However, inflation rapidly increased the cost of power purchased from other systems. New facilities and replacements were much more expensive and carried a much higher rate of interest. Bonneville, being self-financed, faced interest rates comparable to those for investor-owned utilities. As a result, repayment studies conducted in 1977, 1978, and 1979 revealed the need for upward adjustment in many of the 22 rate systems. Between March 1, 1979, and June 15, 1981, 35 rate actions were approved. Of those actions, 17 involved rate adjustments that were sent to the Federal Energy Regulatory Commission for approval on a final basis.

Through these rate actions, a record number for the power marketing program, the power administrations have assured timely repayment of Federal costs. The effect of these rate actions has been to increase power revenues from $715.1 million in fiscal year 1978 to more than $1.2 billion in fiscal year 1981. Revenues are expected to exceed $1.5 billion in fiscal year 1982. Power purchase and resale provisions of the Pacific Northwest Electric Power and Conservation Act may increase Bonneville revenues and expenses an additional $500 million in fiscal year 1982. Repayment studies supporting these rate actions indicate that the new rates will recover costs at the lowest possible rate.

Projected Program Requirements

Fiscal year 1982 budget data for the power administrations are shown in Table 47-2. With fiscal year 1982 appropriations, the power administrations will operate and maintain their power systems; purchase power and wheeling; and construct, replace, and upgrade transmission facilities.

Alaska Power Administration. For fiscal year 1982, Alaska received $1,987,000 for operation and maintenance. For fiscal year 1983, Alaska proposes to operate and maintain the Eklutna and Snettisham power projects and attendant transmission systems and to expand the market for Snettisham power. The cost will be about 10 percent below the 1982 budget.

A 10-percent increase in the budget would permit Alaska to advance by about 8 months completion of studies of the Snettisham underwater cable to serve outlying cities. If the budget is cut by 10 percent, it would be unable to install shunt reactors and replace an over-aged bulldozer.

Alaska received $893,000 for general investigations and $658,000 for program direction in fiscal year 1982. The fiscal year 1983 budget proposes termination of the general investigations activities.

Alaska expects power sales of 385 million kilowatt-hours and revenues of $4.5 million in 1983.

Bonneville Power Administration. For fiscal year 1982, Bonneville received borrowing authority of $279.7 million and predicted a net outlay of minus $55.1 million. In fiscal year 1983, Bonneville plans to operate and maintain the Federal Columbia River Power System in accordance with prudent utility practice. It will purchase power resources to meet contractual obligations pursuant to P.L. 96-501. It will work with customer utilities to expand energy conservation efforts to minimize the need for new generating resources, and it will seek cost-effective renewable energy resources. It will undertake measures to protect, enhance, and mitigate problems affecting fish and wildlife resources of the Columbia River and its tributaries.

Bonneville will design and construct additions to the transmission system to meet customer needs, to improve system reliability, and to interconnect with other regions to exchange power and take advantage of load diversity. It will cooperate with regional utilities in Pacific Northwest power system operations and power planning. In accordance with P.L. 96-501, Bonneville will continue its relationship, by then expected to be well established, with the Pacific Northwest Electric Power and Conservation Planning Council. It also will test and operate three MOD-2 wind turbine generators and will conduct research in ultra-high-voltage transmission, new methods of system operation and control, load forecasting techniques, and related areas.

Under P.L. 96-501, Bonneville's current borrowing authority of $1.25 billion was expanded to include not only construction of transmission facilities but also financial assistance for conservation measures, renewable resources, and fish and wildlife. The act also increased Bonneville's borrowing authority by an additional $1.25 billion, reserved for the purpose of providing funds for conservation and renewable resource loans and grants.

Although Bonneville is self-financed and requires no appropriations, it nevertheless is subject to congressional scrutiny on its budget submission. It anticipates power sales of 203 billion kilowatt-hours and revenues of $1.7 billion.

Southeastern Power Administration. For fiscal year 1982, Southeastern received an operating budget of $1,315,000 and a net purchase power and wheeling budget of $5,922,000 which reflects offsetting receipts of $3,110,000. In fiscal year 1983, Southeastern will have the responsibility to market 3,000 megawatts of Federal power from 21 projects through wheeling arrangements with non-Federal utilities to approximately 250 wholesale customers in 10 states. Energy sales will be about 6.9 billion kilowatt-hours. Southeastern will continue to develop and implement policy applicable to its four systems designed to achieve the sale of all available power and energy to public bodies and cooperatives. Because sales to nonpreference customers will be terminating, as a result of growth in preference customer demand, net billing procedures will no longer be appropriate, requiring appropriations to cover wheeling and firming expenses. Southeastern will require a substantial budget increase in fiscal year 1983, most of which will be for wheeling charges and purchased power. Rates will be increased to produce $71.7 million in revenues, which will include immediate offset recovery of the appropriated moneys.

An increase or decrease in the budget will primarily affect the implementation of the revised contracts for customers in the Georgia-Alabama System. New contracts, to replace contracts expiring in May 1983, will implement the policy of selling all available power to preference customers. An increase or decrease of 10 percent would advance or delay implementation of the new contracts and the additional revenue that would be earned. Southeastern will also seek to reach agreement on wheeling contracts with utilities not now dealing with Southeastern.

Southwestern Power Administration. For fiscal year 1982, Southwestern received an operating budget of $8,521,000, a purchased power and wheeling budget of $9,210,000, and a construction budget of $3,538,000. In fiscal year 1983, Southwestern will operate and maintain its transmission system at acceptable utility standards and expects to sell 5.5 billion kilowatt-hours. It will study opportunities for interregional interconnections, adjust rates to ensure recovery of costs, and contract for right-of-way and transmission line maintenance on a catchup basis. It anticipates revenues of $69.1 million. Because 1981 was a severe drought year, Southwestern drastically drew down its financial reserves for purchased power. It therefore will need sufficient funding authority in fiscal year 1983 to purchase power for at least 5 months should another critical water year occur. Each month requires an expenditure of approximately $4 million. The operating budget is expected to contain a modest increase because of the addition of a new hydroelectric plant in fiscal year 1983.

At an incremental level of 10 percent, Southwestern could undertake a conservation and renewable resource program. A decrement would degrade operation and maintenance of the transmission system. The construction budget would be unchanged from fiscal year 1982. A decrement of 10 percent would eliminate the planning and construction of interconnections with the Southwest Power Pool to increase system reliability and provide voltage support and power transfer capability. It also would eliminate a study of Southwestern's communication system which is in need of improvement.

Western Area Power Administration. For fiscal year 1982, Western received an operations and maintenance budget of $56,174,000, a net purchase power and wheeling budget of $53,200,000 which reflects offsetting receipts of $11,235,000, a construction and rehabilitation budget of $101,400,000, and an emergency fund of $500,000. In fiscal year 1983, Western expects to operate and maintain 16,000 miles of transmission lines and associated power facilities. It anticipates marketing 3 billion kilowatt-hours of energy and receiving revenues of $400 million. Its operations and maintenance budget is expected to be virtually unchanged from fiscal year 1982 and allow for only 70 percent of scheduled maintenance. An increment would permit additional maintenance on existing and recently completed power systems and on transmission facilities transferred from the Bureau of Reclamation. Any budget decrease would further reduce regularly scheduled maintenance work and seriously compromise system reliability. Western plans a continuous transmission line construction program of the same magnitude as fiscal year 1982. This would continue the work on Western's program to upgrade and rehabilitate transmission lines, complete the Miles City-New Underwood transmission line, the East-West AC-DC-AC intertie, and advance Federal participation in work on the 345-kilovolt transmission lines in Colorado and New Mexico. These items will increase significantly Western's capability to generate additional revenues. Construction will be completed on the new operation and dispatch center at Loveland-Fort Collins as well as on other supervisory control and associated communication equipment and maintenance facilities.

A budget decrement of 10 percent would stretch out many ongoing construction projects and delay the start of major transmission upgrades and new energy transfer capabilities. The budget would reduce the purchased power and wheeling program and force Western to purchase excessive amounts of power from the Pacific Gas and Electric Company, which would result in purchases of very high cost oil-fired power as early as 1984-85. Purchasing surplus energy available in the Wyoming and Montana areas, while requiring transmission upgrading, would postpone the need to purchase this very expensive oil-fired power.

Transitional Requirements

Bonneville is self-financed and is not dependent upon the congressional appropriations process. Each of the other administrations--while collecting sufficient revenues each year to cover all current costs of operation and maintenance, purchased power, and wheeling--are nonetheless dependent on appropriations. If appropriations were to be reduced or discontinued for the other power administrations, one approach would be to make them self-financing, paralleling the Bonneville system to the extent appropriate.

Transition to an alternative delivery organization would be extremely complex. Federal hydroelectric power is sold under long-term contracts primarily to local municipal utilities and to rural electric cooperatives. Service cannot legally be curtailed with these customers without arrangements being made for an alternative way to deliver the energy and capacity they have agreed to purchase, and without amending or repealing more than 20 separate acts of Congress.

Unless the generating facilities at Federal dams also were sold, disposal of the transmission systems of the power administrations would not alter the need to market Federal hydropower and to price the power to recover the investment in dams and generating equipment, to repay the cost of the power production, and to obtain assistance for irrigation as required by law.

B.

REVIEW OF ENERGY EMERGENCY PREPAREDNESS PROGRAMS

ENERGY EMERGENCY PREPAREDNESS

<u>OVERVIEW</u> World oil supplies have been disrupted three times in the last decade--at the time of the Arab-Israeli war, the Iranian revolution, and the Iran-Iraq war. The concentration of world oil supplies in a small number of insecure and unstable countries in the Middle East and North Africa suggests that this market will remain subject to disruptions for the foreseeable future.

In the past, the United States has dealt with disruptions by attempting to control domestic oil prices and allocate available oil supplies. These tactics only exacerbated the economic impact of these disruptions by creating gasoline lines and shortages, misallocating available supplies, and subsidizing the consumption of oil imports.

The Administration is committed to a policy of dealing with future supply disruptions by allowing market forces to allocate available oil supplies and by withdrawing stocks from the Strategic Petroleum Reserve. The policy of allowing market forces to allocate oil supplies has two distinct advantages. First, during future disruptions, reliance on market forces will enhance the ability of the economy to adjust, as well as possible, to the dramatically different allocation of resources required by dramatically different world oil prices. In addition, reliance on market forces will minimize the inconvenience and waste from the lines and spot shortages that inevitably accompany government allocation. Second, in anticipation of future disruptions, commitment to such a policy will provide an incentive for private stockpiling and other forms of self-insurance.

The Administration's commitment to dealing with major disruptions of the world oil market by drawing down stocks from the Strategic Petroleum Reserve is intended to deal with the essence of the problem--reduced oil supplies or the expectation of reduced oil supplies--in the most direct manner possible. In order to be prepared to draw down reserves during future disruptions, the Administration has accelerated purchases to fill the reserve, more than doubling its size over the last year.

(48) STRATEGIC PETROLEUM RESERVE (EP)

Program Objectives

The Strategic Petroleum Reserve is an underground petroleum stockpile operated by the Federal Government. Current plans call for a three-phase development. The first phase involved the conversion of existing capacity at five salt dome sites for oil storage and the construction of a marine terminal at St. James, Louisiana, on the Mississippi River. The five sites are Bryan Mound in Texas and Sulphur Mines, Weeks Island, West Hackberry, and Bayou Choctaw in Louisiana. The second phase calls for the expansion of storage capacity at three of the Phase I sites while the third phase involves both the creation of still more storage space at the initial five sites and the acquisition of an additional site. Once the President orders its withdrawal from storage, the oil will be transferred through Government-owned pipelines to petroleum terminals. From these terminals, the oil could be moved either by pipelines or by ships to refineries.

Created by the Energy Policy and Conservation Act of 1975 (P.L. 94-163) on December 22, 1975, the Strategic Petroleum Reserve Program has a very clear goal: to reduce U.S. vulnerability to severe supply interruptions and to meet U.S. obligations under the International Energy Program.

At its inception, the program had the specific objective of storing 325 million barrels within 5 years and approximately 500 million barrels within 7 years. During its first 5 years, the reserve experienced a number of significant policy and program changes. For example, during 1979 and the first half of 1980, oil acquisition was curtailed. The result of this policy was that by the end of calendar year 1980 total reserve storage amounted to only 107.8 million barrels (92.8 million barrels in fiscal year 1980).

In June 1980, the Energy Security Act of 1980 (P.L. 96-294) established the requirement that in each fiscal year the reserve be increased by at least 36.5 million barrels (100,000 barrels per day). Oil acquisition activities to meet this requirement commenced in the summer of 1980 and filling resumed that September. Budget goals announced by the President on March 10, 1981, called for the storage of 168 million barrels of oil by September 30 of the same year.

The Interior and Related Agencies Appropriation Act for fiscal year 1981 (P.L. 96-514) and, subsequently, the Omnibus Budget Reconciliation Act of 1981 (P.L. 97-35) stated that "the President shall immediately seek to undertake, and thereafter continue . . . crude oil acquisition, transportation, and injection activities at a level sufficient to assure that crude oil in storage in the Strategic Petroleum Reserve will be increased at an average annual rate of at least 300,000 barrels per day."

Tables 48-1 and 48-2 provide additional detail on historical and current program objectives. There are no other programs that duplicate the objectives of the Strategic Petroleum Reserve Program.

An alternative to this program is to induce the oil industry and major consumers to stockpile an equivalent amount of oil. However, as the National Petroleum Council's 1981 report Emergency Preparedness for Interruption of Petroleum Imports into the United States points out, "storage of strategic crude oil stocks by the private sector would require the construction of additional storage capacity." The development of storage capacity requires significant lead time; the Government has already invested $1.5 billion and 5 years in facilities development for the reserve. Therefore, it is not feasible to substitute induced private sector stockpiling for the Strategic Petroleum Reserve Program. Private sector inventory development can serve, however, as a useful complement to the reserve.

Program Results

The original objectives of the Strategic Petroleum Reserve Program, as envisioned in 1975, have been incorporated into the development of the program and are being achieved. The major variance between planned and actual performance relates to the original schedule targets in the Energy Policy and Conservation Act, which proved to be impractical.

Given its essential function as a national insurance policy, the most important results of the program would emerge during a serious supply interruption. The availability and use of the Strategic Petroleum Reserve under this condition would reduce oil price levels, lower general price inflation to some degree, decrease the transfer of wealth to oil-exporting nations, and increase the gross national product above what it would be if there were no reserve. In addition to these economic impacts, the Strategic Petroleum Reserve Program provides the United States with a clear strategic element by enhancing national defense and by adding flexibility to foreign policy.

Some program consequences are already discernible. For instance, Government borrowing levels are higher during Strategic Petroleum Reserve development than they would be without the reserve. Federal borrowing for the reserve competes with other potential uses for the same funds by the private sector and thus has some effect on credit availability. However, the Strategic Petroleum Reserve consists of an appreciating asset readily convertible to cash, so that the long-term net effects of the program on Federal finances are likely to be less severe than any near-term annual budget effects.

Since most of the reserve's funds are spent on the acquisition of crude oil, the program has a minimal impact on employment and productivity. Some employment opportunities have been created at reserve sites during development and in the pipeline and heavy equipment industries. Because the oil acquisition activities are designed to reflect market conditions, the program has had no major adverse impact on the oil industry. Similarly, the program has had no significant impact on local tax bases or local demand for services.

The major environmental issues arising from the program are the location of reserve facilities in coastal wetlands, oil spills, hydrocarbon emissions, and the impact of large-scale brine disposal on the marine environment. In all cases, these are insignificant nationally. The impact on wetlands (and on land in general) is minimized as a result of underground storage. Oil spills have occurred, but the Department has been able to avoid any significant long-term effects, even in the case of a major spill at a Strategic Petroleum Reserve site. The effect of emissions for the reserve on local ambient air quality are under constant and intense study, as is the brine discharge which to date has shown no measurable effect on the marine environment.

The program has been subjected to continuous congressional oversight and review, and even though original targets were not met, the direction of the program is consistent with congressional intent. In 1980, Congress expressed its concern about the curtailment of Strategic Petroleum Reserve Program oil acquisition under the prior Administration. During 1981, the current Administration substantially increased petroleum acquisition and thus alleviated congressional concern.

The Department is moving to achieve a total storage level of 750 million barrels by 1990 in a secure and reliable system capable of crude oil withdrawal of up to 4.5 million barrels per day. Phase I of the program, consisting of 250 million barrels of storage facilities, was completed in 1981. Phase II, consisting of an additional 290 million barrels of capacity by 1986, is under way, and fill of Phase II storage caverns has begun. An implementation plan for Phase III has been approved, with initial development funding secured in the fiscal year 1982 budget. Table 48-1 depicts program accomplishments and expenditures during the past 4 years.

Projected Program Requirements

The fiscal year 1982 budget authority for the Strategic Petroleum Reserve totals $3,875,432,000 of which $3,684,000,000 is for the off-budget SPR Petroleum Account. Fiscal year 1983 plans call for increasing the storage capacity and oil inventory for the reserve from 267 million barrels at the end of fiscal year 1982 to 343 million barrels by the end of fiscal year 1983. Concurrently, Phase III facilities development will continue. Table 48-2 reviews projected activities.

In May 1978, Congress approved Strategic Petroleum Reserve Plan Amendment No. 2, providing for ultimate reserve expansion to 1 billion barrels and implementation of a reserve of 750 million barrels. The timing and method of the final 250 million barrels have not been determined. Under current plans, the full 750-million-barrel reserve should be completed by fiscal year 1990.

A 10-percent budget authority increase would enable the Department to contract in fiscal year 1983 for an additional 5 million barrels of oil for fiscal year 1984 delivery. A 10-percent funding decrease would reduce by 5 million barrels the oil contracted for in fiscal year 1983 for delivery in fiscal year 1984. Whether either an increase or decrease of this magnitude would affect the actual delivery schedule depends on the nature of oil market conditions in fiscal year 1984.

Transitional Requirements

Discontinued funding of the Strategic Petroleum Reserve would require disposition of the stored oil and storage facility pipeline and terminal assets, and payment of contractors' damages.

(49) ENERGY EMERGENCY PREPAREDNESS (EP)

Program Objectives

The overriding purpose of the Energy Emergency Preparedness Program is to reduce the Nation's economic vulnerability to energy supply disruptions. The strategy to achieve this objective relies primarily on the marketplace to allocate energy supplies. Within this market-based strategy, the Government program emphasizes the removal of barriers to short-term adjustments in the marketplace. Although the Government program always has sought to reduce the impact of supply disruptions on the domestic economy, the strategy for accomplishing this goal has been modified. The extensive Government intervention practiced in previous supply disruptions, particularly the imposition of price and allocation controls and demand restraint measures, has been abandoned because it exacerbated the adverse economic impacts of supply disruptions.

The Energy Emergency Preparedness Program is divided into two subprograms: Energy Contingency Planning and Emergency Operations. Energy Contingency Planning is the focal point for energy contingency planning and emergency mobilization preparedness. Through this subprogram, the Government satisfies defense and national security energy requirements, develops Strategic Petroleum Reserve drawdown procedures and use options, develops plans to support U.S. participation in NATO energy emergency organizations and in the International Energy Agency, analyzes policy issues associated with energy supply emergencies, develops and conducts tests of response plans and the emergency management structure, and assesses the effects of energy emergency scenarios. It also enables the Government to respond appropriately to energy disruptions by developing emergency information procedures and response measures designed to facilitate the operation of the market during emergencies. This capability allows policy-makers to minimize the effects of disruptions on the economy and national security consistent with free-market operations.

Emergency Operations has the capability to assess and react to energy emergencies as they develop. It also ensures the operating capability of the Emergency Manpower Reserves to respond to fuel supply problems, assesses supplier and consumer efforts to cope with emergencies, implements emergency responses, and analyzes supplies of petroleum, natural gas, solid fuels, and electricity.

The Energy Emergency Preparedness Program has an extensive legislative mandate. Sections 202 and 251 of the Energy Policy and Conservation Act of 1975 (P.L. 94-163) authorize the United States to meet its obligations under the International Energy Agency and to restrict the public and private use of energy. The Emergency Energy Conservation Act of 1979 (P.L. 96-102) authorizes restrictions on the end-use of energy. The Defense Production Act of 1950 (P.L. 81-774, 50 U.S.C. App. 2061, et seq.) provides authority to allocate oil supplies for national defense purposes should it become necessary during a major disruption. Executive Order 11490, as amended, assigns emergency preparedness functions to Federal agencies dealing with petroleum, natural gas, solid fuels, and electric power. Section 404 of the Powerplant and Industrial Fuel Use Act of 1978 (P.L. 95-620) and the waiver authority under section 110(f) of the Clean Air Act Amendments of 1977 (P.L. 95-95, 42 U.S.C. 7410) encourage fuel switching and increased efficiency in fuel use.

Section 202 of the Federal Power Act (16 U.S.C. 792 et seq.), provides an additional legislative mandate to deal with electricity-related emergencies, such as issuing orders for emergency interconnections and developing electricity emergency plans. Section 232(b) of the Trade Expansion Act of 1962 (P.L. 87-794) provides authority to impose fees and quotas on oil imports based upon findings that oil imports threaten national security. Sections 301 to 304 of the Natural Gas Policy Act of 1978 (P.L. 95-621) provide emergency authority related to natural gas supplies during a severe shortage. Section 607 of the Public Utility Regulatory Policies Act of 1978 (P.L. 95-617) provides authority to prohibit the burning of natural gas by any electric powerplant or major fuel-burning installation. Authority also exists under the International Emergency Economic Powers Act of 1978 (P.L. 95-223) to declare a national emergency to deal with any unusual and extraordinary threat to the national security, foreign policy, or economy of the United States.

No other program within DOE has duplicate objectives. In the absence of these programs, assessments of energy supply vulnerability would consist of those performed by private industry.

Program Results

The original Energy Emergency Preparedness Program focused on price and allocation controls (rescinded by President Reagan on January 28, 1981). This program sought to help small refineries, local and state governments, and certain high-priority users. The allocation program also addressed spot shortages of oil and the oil requirements of the Department of Defense during shortages or periods of unusual demand. The Energy Emergency Preparedness Program also prepared analytical reviews of potential international supply interruptions and preliminary contingency plans; conducted utility-related evaluation of supply adequacy; developed handbooks, planning guides, computerized data bases, and other information collections for states and industry; and responded to legislative requirements for a gasoline rationing plan and state emergency conservation measures. Table 49-1 provides greater detail about program accomplishments and expenditures during the past 4 years.

The allocation and price control system had very serious adverse consequences. It constrained production during periods of adequate supply; created a disincentive for private stockpiles; created the inefficient distribution of supplies that contributed to gasoline lines in 1973-74 and 1979; and subsidized imports, thereby adding upward pressure on world oil prices.

The current program, with its emphasis on market allocation, will ensure the most efficient allocation of available supplies in the short run and will lead to higher reliance on domestic production and accumulation of larger private inventories for use during emergencies in the long run. Ultimately, the program will reduce adverse economic impacts such as unemployment and inflation and will enhance defense preparedness.

As a result of the reorganization of the Department of Energy in 1981, the United States is well positioned to direct the development of coherent and integrated emergency contingency plans dealing with oil supply disruptions and other energy emergencies. The reorganization for the first time placed nearly all contingency planning and emergency preparedness responsibilities within a single office, headed by the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness. Included within this office are the Strategic Petroleum Reserve Program, the Naval Petroleum and Oil Shale Reserves program, and the Office of Energy Emergencies.

Projected Program Requirements

The fiscal year 1982 budget authorization for the Energy Emergency Preparedness Program is $10.1 million. These funds will enable the Department to develop comprehensive energy emergency preparedness measures to enhance the market distribution of energy supplies, to meet national defense requirements, to fulfill U.S. commitment to the NATO Civil Emergency Preparedness Organization and the International Energy Agency (IEA), and to continue working relationships with state and local governments. Future work includes performing risk assessment and vulnerability studies; developing public education and information programs; developing and maintaining an energy situation reporting system to warn of potential energy emergencies; participating in IEA oil-sharing, Defense Department, and Federal Emergency Management Agency tests and exercises; and reactivating executive reserves and related advisory groups to ensure operational readiness. Table 49-2 provides additional details on plans and projected requirements.

A 10-percent funding increase would enhance the support provided to the Emergency Preparedness Mobilization Board, which was approved by the President on December 17, 1981. A 10-percent decrease in funding would reduce the level of participation in activities of the International Energy Agency, including participation in the Allocation System Test-4 and related analytical and contractual work.

Transitional Requirements

The Department has no legislative recommendations to ameliorate any disruptive effects that might result should funding for this program be discontinued. Funds would be required for contract termination costs. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

C.

REVIEW OF
DEFENSE PROGRAMS

OVERVIEW

The Department's defense activities, which are funded by the Atomic Energy Defense Activities Appropriation, support the nuclear-related national defense objectives of the United States. Within the Department, these activities are organized into programs, described in the program analysis units which follow, and these programs are the responsibility of two assistant secretaries. The Assistant Secretary for Defense Programs (ASDP) administers the Nuclear Weapons Activities, Materials Production, Defense Waste Management, Inertial Confinement Fusion, Verification and Control Technology, and Nuclear Materials Security and Safeguards programs.

The technology developed by the Naval Reactors Development Program during the early 1950's formed the basis for the civilian application of light water reactors and continues to contribute to the nuclear fission development effort. Because of the close tie-in between its technology and that developed for other nuclear energy programs, the Naval Reactors Development Program is placed organizationally under the cognizance of the Assistant Secretary for Nuclear Energy (ASNE). For budget purposes, however, the program is funded within the Department's atomic energy defense activities mission area.

Character of Defense Activities

The principal products of the Department's defense activities are the Nation's nuclear weapons, the nuclear materials for use in the weapons and for use in other Federal research and development programs, the management of the resultant radioactive waste, and the technology and fuel cycle support for the Navy's nuclear propulsion systems. There are also other products described in the program analysis units which follow, but the main point is that <u>all</u> of the defense activities contribute directly or indirectly to at least one of these principal products. The Uranium Enrichment Activities, the responsibility of the Assistant Secretary for Nuclear Energy, is the remaining DOE activity essential to the Department's defense activities and is discussed in PAU #46, "Uranium Enrichment Activities."

This group of activities has been successfully functioning for more than 35 years, and there is a continuing need for its outputs into the foreseeable future. New nuclear weapons and their contained materials will be needed for use in new Department of Defense weapons systems, and the checks and balances role exercised over safety, security, and control of weapons in the custody of the armed forces will continue. Improved naval reactors will be needed to power future ships for the Navy.

In fiscal year 1982, the defense activities budget is about $4.7 billion. Some 58,000 contractor and 2,600 Federal employees are involved at approximately 20 principal contractor sites and 8 field offices.

The programs are integrated and interdependent. The nuclear Materials Production Program produces and supplies plutonium and tritium in the quantities and on a schedule required by the Weapons Program, which in turn delivers weapons to meet the requirements of the Department of Defense. Additionally, Materials Production provides nuclear materials for Federal research and development programs, and also receives and processes the Navy's spent reactor fuel, recycling the recovered materials back into its plutonium and tritium production reactors. The Inertial Confinement Fusion Program complements the weapons research and development effort. Verification and Control Technology relies on Weapons Program technical expertise in discharging its treaty verification and arms control responsibilities. The Defense Waste Management Program is responsible for the safe and environmentally acceptable storage and ultimate disposition of the materials production and other defense-related radioactive waste generated by the Department. The Nuclear Materials Security and Safeguards Program supports the other activities by developing policy, providing oversight, and performing research and development in improved nuclear material control and accountability techniques and physical security systems. Uranium Enrichment Activities, not formally a part of the defense activities, provide enriched uranium for the weapons, naval reactors, and materials production work.

Accordingly, the separate defense activities are not to be viewed singly, but rather as a one-of-a-kind, integrated, interdependent whole, made up of the management offices, laboratories, test facilities, and materials and weapons production sites that must be retained and managed as a unit.

<u>Importance of Program Diversity to Weapons Laboratories</u>

The nuclear weapons laboratories (Los Alamos National Scientific Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories) are vital to the defense activities, since they are responsible for the weapons research, development, testing, and ordnance engineering, including stockpile maintenance and design safety features. It is essential to the Nation's defense that the strength, vitality, and technical excellence of these laboratories be nurtured and further developed in the future.

The current mission of these laboratories, in addition to their weapons work, includes research and engineering in a broad spectrum of energy technologies. This breadth of technical responsibility is a key factor in the ability of these organizations to maintain their vitality and expertise by recruiting the best technical staff members and continuing to challenge them with varied and interesting work. For these reasons, the assignment of nondefense energy technology work to the weapons laboratories, under the condition that it does not interfere with their primary mission, enhances the well-being of the laboratories.

Conversely, without the nonweapons research and development work, the weapons laboratories would suffer some retrenchment.

Protection of Classified Information

Another essential activity under the Assistant Secretary for Defense Programs, but funded through the Departmental Administration Appropriation (changes to Atomic Energy Defense Activities Appropriation in fiscal year 1983), is the provision for the protection of information critical to our national security through the Classification Program. Because of its small size and cost (approximately $1.6 million in fiscal year 1982), the Classification Program is not treated as a separate Program Analysis Unit. However, because of its importance to the defense activities of the Department, and indeed the Government as a whole, it merits coverage in this report.

Specifically, the mission of the Classification Program is to establish and implement policy for the classification of Restricted Data, Formerly Restricted Data, and National Security Information within the Department of Energy's jurisdiction in accordance with the requirements of the Atomic Energy Act of 1954 (P.L. 83-703), as amended, and as prescribed in applicable Executive orders. The program must also ensure the continuous review of Restricted Data and other classified information in order for the Assistant Secretary for Defense Programs to determine what may be declassified and disseminated in the interest of scientific and technical progress and the general public welfare, without damage to the national security.

Sunset Analysis Topics Common to All Defense Activities

Several of the topics contained in Title X of the Department of Energy Organization Act may be adequately addressed for defense activities as a whole, as opposed to repeating similar information in each of the program analysis units.

The defense activities programs are technical in nature, and alternative means for achieving the technical and operational ends discussed above are not obvious. Likewise, given the legislative reservation of these activities to the Federal Government and the assignment of that responsibility by law to DOE, in general, there are not duplicative programs elsewhere, inside or outside of the Government.

The prime beneficiary of these programs is the Nation as a whole, whose general welfare is enhanced by our position of world leadership and by our strong defense posture--a large part of which depends on our nuclear weapons and nuclear Navy. A secondary beneficial effect stems from technological spinoff to the Nuclear Regulatory Commission, the Department of Defense, other Federal agencies, and the private sector.

Regarding the effect of these programs on the national economy, there is no positive or negative impact apart from the fact that the appropriated funds are cycled back through salaries paid to the Federal and contractor work force and through the funds expended for goods and services in conducting the program. In the current fiscal year, the sum of these outlays is estimated to be about $4.5 billion. This money is spent by contractors and Federal offices located in 15 states for procurements from a wide diversity of suppliers and subcontractors.

The nature of the work necessarily involves such specialized activities as the operation of nuclear reactors, conduct of nuclear fuel cycle activities including radioactive waste management, fabrication of plutonium metal parts, work with high explosives, and conduct of nuclear weapon tests, in addition to more routine research, development, and manufacturing activities characteristic of other Government or private endeavors. Due care and caution have been and continue to be exercised in the conduct of all defense activities work, so that neither the public nor the personnel involved are exposed to health, safety, or environmental risks beyond those routinely permitted by regulation for similar licensed or other comparable industrial activities. A decontamination and decommissioning program is in place to manage, clean up, and dispose of defense activity facilities which are no longer programmatically required. Accordingly, the impact of these activities on the Nation's health and safety is negligible.

Overall, it is considered that the defense activities have met the objectives and the expectations of Congress.

(50) NAVAL REACTORS DEVELOPMENT (NE)

Program Objectives

The Naval Nuclear Propulsion Program is an integrated program of the Departments of Energy and Navy. The director of the program serves as the Deputy Assistant Secretary for Naval Reactors. He is responsible for reactor plant research, design, development, construction, operation, maintenance, control of radioactivity, and environmental matters pertaining to naval nuclear propulsion plants as well as related reactor plant safety aspects. These responsibilities include selection, training, qualification, and recommendation for assignment of personnel for operating and maintaining these plants. These responsibilities also include all nuclear propulsion technical aspects involved in gaining acceptance by approximately 50 foreign governments for the entry of U.S. nuclear-powered warships into their ports.

Within this integrated program, the Navy is responsible for the military applications of nuclear propulsion including constructing, operating, and maintaining nuclear-powered ships, and for developing the nonreactor portions of the nuclear propulsion plants. The Department of Energy is responsible for the research, development, and safety of nuclear reactors for warships. It is also responsible for the construction and operation of land-based prototype nuclear propulsion plants for conducting long-term tests to assess performance under extremely demanding conditions over many years. These program responsibilities have remained substantially unchanged during the past three decades.

The objectives of the Naval Nuclear Propulsion Program development effort are the following:

- Development of long-lived cores with the intention of ultimately developing cores that will last the life of the ship
- Development of advanced design reactor plant components and component technology
- Development of higher power reactors
- Assurance of safe and reliable performance by naval nuclear propulsion plants

Within the Naval Nuclear Propulsion Program, the DOE Naval Reactors Development Program provides for the design, development, testing, and evaluation of improved naval nuclear propulsion plants and reactor cores having long fuel life, high reliability, improved performance, and simplified operating and maintenance requirements. The nuclear propulsion plants and cores cover a wide range of configurations varying in size from small submarines to large surface ships.

The Department of Energy Organization Act of 1977 (P.L. 95-91), mandates that Naval Reactors has responsibility for research, design, development, and health and safety matters pertaining to naval nuclear propulsion plants and assigned civilian power reactor programs. This derivation of responsibilities allows the program to develop naval nuclear propulsion plants and to ensure their safe and efficient operation. Section 309(a) of the act stipulates that the Division of Naval Reactors, established pursuant to section 25 of the Atomic Energy Act of 1954 (P.L. 83-703), is an organizational unit in the Department of Energy and is to be assigned to the assistant secretary having responsibility for energy research and development programs. This is because the research and development effort performed by Naval Reactors is directly applicable to, and inherently part of, DOE's nuclear fission energy program. Naval Reactors has been the source of much of the technology for the civilian nuclear energy industry, including development of the first large central-station nuclear powerplant. This organizational arrangement allows the most effective interchange of reactor development and safety technology to the benefit of all DOE nuclear programs.

Program Results

The Naval Nuclear Propulsion Program continued to pursue the objectives noted above. By successfully applying nuclear power to warships, the program has made possible a revolution in naval warfare. Today, nuclear-powered ships constitute more than 40 percent of the Navy's combatant fleet. This includes 119 submarines plus 31 more authorized or under construction and 12 surface ships plus 2 others authorized or under construction. With each new submarine and surface ship class has come design and technological advances in the nuclear propulsion plant. For example, the first nuclear core in the Nautilus provided power for 62,000 miles of steaming. The nuclear core in the latest class of high speed nuclear-powered attack submarines, the Los Angeles Class, will be good for approximately 400,000 miles.

Naval Reactors also has made major contributions to the Nation's nuclear power program. Among these are the following:

- The development of a uranium-dioxide fuel system--now the most widely used fuel system in nuclear power.

- The pioneering of the design of a number of large pressurized water reactor components including the advancement of technology for producing and cladding large pressure vessels.

- The development of the first large-scale, central-station nuclear powerplant in the United States.

- The development of containment concepts and refueling techniques for power reactors.

- The submission of the first safeguards report for a commercial nuclear power station.

- The development of a system for preventing damage to a reactor core even if failures occur in the cooling system.

- The first successful method of radioactive decontamination of reactor plants.

- The development of zirconium, zirconium alloys, boron, and hafnium materials for use in nuclear reactors. These materials are essential for cladding and reactor control.

- The development of a self-sustaining breeder reactor cooled with ordinary water and using thorium/uranium-233 fuel.

In addition to the above areas, the Naval Reactors Development Program is a valuable source of technical information and expertise to industry. Naval Reactors is a leader in such areas as corrosion and wear technology for components operating in high-temperature, high-pressure water; pressurized-water-reactor heat-transfer and fluid-flow technology; predicting the performance of reactors in accidents; improving numerical analysis and reactor design techniques for digital computers; and has made a number of important developments in reactor physics and in determining the irradiated properties of uranium fuels. Naval Reactors also is a leader in the development of equipment specifications, fabrication standards, and quality control requirements for nuclear components for both naval and civilian applications. Technical advances in these areas have been made known to the industrial community in more than 5,000 published reports.

These achievements are due to an evolutionary process based on more than 30 years of reactor engineering experience in designing, developing, and improving nuclear propulsion plants. To fully carry out safety responsibilities and to receive operating plant data to incorporate in ongoing development efforts, the program technically oversees nuclear propulsion plants from the inception of plant development efforts through decommissioning of nuclear-powered ships.

A major contribution to industry has been the highly trained personnel who have left the Navy and now play key roles in the operation and management of reactors in the civilian nuclear power industry. In 1973, a former Chairman of the Atomic Energy Commission estimated that the value to the utilities and their customers of not having to train these people was about $2.5 billion.

To ensure safe, reliable, and environmentally acceptable nuclear propulsion plants requires constant consideration in the design and development of equipment, the training of operators, and the inspection, overhaul, and refueling of nuclear propulsion plants. The success the Naval Nuclear Propulsion Program has had in fulfilling this responsibility has resulted in nuclear-powered warships and land-based prototype plants achieving more than 2,300 reactor-years of operation during the last 27 years without an accident involving a reactor. The total occupational radiation exposures for personnel operating ships and for employees in the shipyards has been reduced to about one-sixth the amount in the peak year, 1966, even though the number of nuclear-powered ships has nearly doubled.

During the fiscal years 1978 to 1981 period, some of the accomplishments included adding 13 nuclear-powered warships to the Navy's fleet; carrying out 22 refuelings; commencing operation of the Trident prototype nuclear propulsion plant; successfully completing sea trials of the first Trident ballistic missile submarine (USS Ohio); installing the Advanced Submarine Plant reactor in a prototype nuclear propulsion plant; initiating procurement of the prototype Advanced Fleet Core (a possible significant advance in reactor core technology); reducing personnel radiation levels, which were already well below Federal limits; and, as a benefit of operating the prototype nuclear propulsion plants, training about 15,000 nuclear plant operators for the Navy. Table 50-1 expands on the program's accomplishments. Table 50-2 provides a general overview of fiscal year 1982 efforts. The information in the tables is presented in a broad unclassified manner.

Additionally, as part of a separately funded program, Naval Reactors commenced commercial operation of a light water reactor in the Shippingport Atomic Power Station. Details on this effort are provided in PAU #20, "Breeder Reactor Systems."

Projected Program Requirements

The enacted budget for fiscal year 1982 is $359.2 million. These funds are needed to continue current programs and to be responsive to defense requirements as potential adversaries continue their technological advances. Development work on reactor plant concepts provides the Navy with options for future nuclear-powered warships and generates improvements that benefit the operating fleet.

Increases above projected levels will not ensure that objectives and goals of the program will be more rapidly met. Technical advances are not brought about by an influx of money, but rather by proceeding at a measured pace.

A reduction in funding would cause disruption and inefficiency in developmental efforts. This in turn would lead to higher overall costs and programmatic delays. The effect of reduced funding on developmental efforts cannot be specifically identified because technical support of operating reactor plants must receive priority and the level of this effort is not completely predictable. Reduced funding would ultimately result in outmoded naval nuclear propulsion technology and in the loss of highly skilled and experienced engineers from the laboratories.

Projected funds for fiscal years 1983 through 1987 are intended to support the following programmatic efforts:

- Extending reactor core endurance to the life of a naval vessel and developing reactors with increased power capabilities. This activity will focus on both material and reactor design, embracing such elements as improved fuel materials and designs capable of withstanding increased irradiation damage due to longer time-at-operating conditions.

- Improving performance of plant components and systems essential to continuity of propulsion plant operations. Determining long-term reactivity behavior and material response in core concepts to overcome the hostile environment in which the cores must operate.

- Continuing to operate prototype plants and to develop advanced servicing equipment in order to test developmental propulsion plants and individual cores and to ensure continued operation of naval fleet reactor plants.

Transitional Requirements

As long as there exists a need for nuclear-powered naval warships, there will be a continuing need for Naval Reactors as part of whatever Government agency is charged with responsibility for development of nuclear technology. Single agency control over the development of nuclear technology has been a national tenet since the original Atomic Energy Act of 1946 (P.L. 79-585) was enacted. This function has been carried out for both commercial and military applications by the Atomic Energy Commission, as well as by its successor agencies, the Energy Research and Development Administration and the Department of Energy. To discontinue the Naval Reactors Program would risk support of a major part of the U.S. defense effort, requiring substantial legislative changes, shutdown of developmental facilities, and dissolution of a highly skilled and experienced labor force.

(51) MATERIALS PRODUCTION (DP)

Program Objectives

The nuclear Materials Production Program of the Department of Energy provides the nuclear materials used in the development, testing, and production of nuclear weapons for national defense. Materials Production also receives and processes the Navy's spent reactor fuel, recycling the recovered materials back into its plutonium and tritium production reactors. The program also provides nuclear materials for Government research and development programs such as the breeder reactor, civilian programs which use radioisotopes in commercial applications, and U.S. allies under mutual defense agreements. These objectives have guided the program through fiscal years 1978 to 1981 and are expected to continue in the future.

Under Chapter 5, sections 41 to 44 of the Atomic Energy Act of 1954 (P.L. 83-703), as amended, the Atomic Energy Commission (AEC) was authorized and directed to produce, or to provide for the production of, special nuclear materials. The Energy Reorganization Act of 1974 (P.L. 93-438) transferred the AEC functions to the Energy Research and Development Administration (ERDA). Section 301 of the Department of Energy Organization Act (P.L. 95-91), transferred the specific ERDA nuclear material production functions to the Department of Energy.

The annual nuclear Materials Production goals are determined from the annual DOE Materials Management Plan (MMP) based on the weapon production plan identified in the annual Presidential Stockpile Memorandum. These objectives are met through the operation of the production reactor feed plants at Fernald and Ashtabula, Ohio, and Oak Ridge, Tennessee; the N Reactor, a fuel fabrication plant, a chemical processing plant, and other support facilities at Richland, Washington; three nuclear materials production reactors, two chemical processing plants, a fuel fabrication plant, and other support facilities at Savannah River, South Carolina; and a chemical processing plant and supporting facilities at Idaho Falls, Idaho. Operations at Idaho Falls include receipt, storage, and processing of fuels both from Navy propulsion reactors and Government and civilian test reactors for recovery and reuse of the remaining enriched uranium.

Another objective is to be prepared for the future consistent with the multiyear production requirements identified in the MMP. Meeting this objective requires a number of new initiatives in order to continue planned production outputs.

Accomplishments and budgetary costs for prior years are shown in Table 51-1.

Program Results

The Materials Production Program has been, and is, meeting its primary objective of providing tritium and plutonium for nuclear weapons. Production levels for these materials are based on a Nuclear Weapons Stockpile Memorandum that is developed annually in conjunction with the Department of Defense and approved by the President.

Since the majority of materials being produced are directed to the defense of the United States, the program directly benefits the total population of our country and is vital to individual and institutional survival. Those areas of production that are undertaken for nonweapons objectives also contribute to both the Government and private enterprise. The fuel-grade plutonium that is produced for energy research and development is essential to the success of the breeder reactor development program. Isotopes are needed for oil well logging and smoke detectors; krypton-85 for testing of electronic components; californium-252 for neutron sources for medical research; and special isotopes for use in defense and space program satellites. While the socioeconomic impact of these operations is significant at the local level, on a national level the program is not a major factor in the Nation's economy.

Planned quantities of material were produced in each of the fiscal years 1978 to 1981 as follows: three production reactors were operated at Savannah River to produce the required quantities of weapon-grade plutonium, tritium, plutonium-238, and other radioisotopes for the national defense program, other Federal programs, and industry. The N Reactor at Richland produced planned quantities of fuel-grade plutonium and delivered by-product steam to the Washington Public Power Supply System to generate electrical power for the DOE Bonneville Power Administration power grid. Fuel and target fabrication facilities were operated to support reactor activities. Slightly enriched uranium billets for N Reactor fuel and depleted uranium target cores for the Savannah River reactors were produced by Oak Ridge at the Feed Materials Production Center in Fernald, Ohio, and at the Extrusion Plant in Ashtabula, Ohio. The Y-12 Plant in Oak Ridge processed enriched uranium received from the Idaho Fuel Processing Facility and from the Savannah River Plant and returned uranium metal to Savannah River for use in fabricating enriched uranium fuels. Processing of production and nonproduction reactor fuels, scrap nuclear materials, and operation of tritium extraction and isotope recovery facilities continued. Program objectives in the form of production output were met in current years with funding as follows (in millions): fiscal year 1978--$399.8; fiscal year 1979--$452.1; fiscal year 1980--$490.3; and fiscal year 1981--$667.0.

At Lawrence Livermore National Laboratory and Los Alamos National Scientific Laboratory, a Special Isotope Separation Program was undertaken for the separation of useful isotopes. Process development efforts continued at Savannah River, Richland, and Idaho toward development of new and improved processes and procedures to improve operating efficiency, increase operational safety, reduce personnel exposure to radioactive materials, improve environmental protection, and ensure the long-term viability of production programs.

One of the prime objectives of the program is to produce nuclear materials in a safe, secure, and environmentally acceptable manner. To this end, considerable emphasis is placed on safe operation of these facilities. The Materials Production Program has operated safely since its inception in the 1940's. Safety concern has and will continue to be exercised in the performance of the nuclear materials production operations, such that the public or the personnel involved are not exposed to significant health, safety, or environmental risks.

Measurement of program performance is accomplished by comparing material production outputs against established nuclear material production planning as identified in the annual Department of Energy MMP. Year-by-year performance accomplishments and budgetary costs are identified in Table 51-1.

Projected Program Requirements

The Departmental funding enacted for fiscal year 1982 is $913.4 million. The increased funding levels are required for increased production of nuclear materials to meet increased national security requirements. In addition to continuing operation of the reactors, processing canyons, and supporting facilities, the funding also provides for continuation of initiatives introduced in fiscal year 1981 to increase production capability in order to meet our anticipated needs. These initiatives include converting the N Reactor at Richland, Washington, from the production of fuel-grade plutonium to weapon-grade plutonium; upgrading of the PUREX fuels processing plant at Richland to allow future recovery of plutonium from irradiated N Reactor fuel; upgrading of a standby reactor (L) at Savannah River, South Carolina, for subsequent restart; restoration of existing production reactors and associated facilities to offset the continued decline in production that has developed because of plant aging; and the production of high-purity plutonium at Savannah River for blending with existing fuel-grade plutonium to yield additional weapon-grade plutonium. The Special Isotope Separation Program will continue toward technology development, prototype demonstration, and construction of a production-scale facility for separation of useful isotopes. A program will be conducted evaluating design options for a Replacement Production Reactor. Studies will be made for expansion and modification of the existing fuel processing facilities for reprocessing spent fuels in support of the DOE breeder reactor programs. Efforts will be expanded in the safety areas in order to implement revised nuclear safety directives. Program objectives and anticipated needs are shown in Table 51-2.

Completion of these initiatives, in accordance with the currently planned schedule, will allow the Department of Energy to meet nuclear materials requirements as specified in the current fiscal year 1981 to fiscal year 1983 Nuclear Weapons Stockpile Memorandum.

The amount of nuclear material produced annually is directly related to the funding provided for the program. A 10-percent increase in funding will permit acceleration of such program activities as the restoration program, thereby restoring previous production efficiencies over a shorter time period. This would help ensure that the requirements of the currently approved Nuclear Weapons Stockpile Memorandum are met.

A budget reduction of approximately 10 percent would delay L Reactor restart, PUREX restart, and N Reactor conversion and would require a force reduction at the major production sites.

Transitional Requirements

Termination of funding for this program would disrupt the U.S. national defense program. Were such termination to occur, there would be substantial costs involved in placing and maintaining the facilities in a safe standby condition. The four reactors currently operating would have to be shut down, decontaminated, and decommissioned to leave them in a condition whereby they would not pose a hazard to public health and safety. Similar steps also would be necessary for the plutonium and uranium processing facilities.

(52) NUCLEAR MATERIALS SECURITY AND SAFEGUARDS (DP)

Program Objectives

The DOE Nuclear Materials Security and Safeguards Program is structured to anticipate and prevent successful execution of threats to national security, which might arise out of malevolence directed toward Department activities--particularly those defense programs activities associated with the production of nuclear materials and weapons and nuclear energy-related programs in which material that is attractive to malevolent interests is present. For purposes of this review, the Nuclear Materials Security and Safeguards Program includes two budget categories: Security Investigations and Nuclear Materials Security and Safeguards Development. Program goals and objectives have remained constant over the period covered by the report. Anticipated needs for continued achievement of program goals/objectives are displayed in Table 52-2.

Under the cognizance of the Office of Safeguards and Security (OSS), the program has the following four goals:

- To prevent unauthorized disclosure, theft, destruction, or loss of classified items
- To provide a base of safeguards and security technology and information directed toward assisting in the protection of Department facilities, and the control and accountability of nuclear weapons, materials, and components to minimize the success of malevolent acts that would affect DOE operations and national security
- To minimize adverse consequences resulting from malevolent acts or threats involving Department activities and provide assistance to other agencies in responding to malevolent nuclear acts or threats potentially affecting national security or the U.S. public
- To strengthen international safeguards and physical security to deter diversion of nuclear materials and to support non-proliferation and national security

While developing and providing implementation oversight for DOE security and safeguards policy, this program interfaces with budget planning activities for all Department organizations which have requirements for safeguards and security expenditures. These eight DOE program elements are:

- Nuclear Weapons Activities
- Materials Production

- Naval Reactors Development
- Breeder Reactor Systems
- Defense Waste Management
- Uranium Enrichment Activities
- Basic Energy Sciences
- Nuclear Materials Security and Safeguards

The Nuclear Materials Security and Safeguards Program's specific budget (one of the above eight) primarily provides funds for research and development for effective safeguards and security technology and for security investigations. The other DOE program elements are directly responsible for the protection of Department facilities under their cognizance and control of associated budgets. The Nuclear Materials Security and Safeguards Program develops the departmental policy for security and safeguards to be implemented at these facilities. In addition, this program conducts independent inspections to provide the review needed to ensure that the DOE operations offices are properly carrying out their safeguards and security responsibilities, thus ensuring that the physical protection and safeguards systems in place are providing effective protection. The program tracks Department of Energy program office budget planning for the correction of identified deficiencies with regard to departmental safeguards and security policy.

This program shares objectives with other Government departments and agencies (principally, the Nuclear Regulatory Commission and the Department of Defense), the private sector, and other countries. It complements and supplements the others in moving toward these objectives and draws upon the unique skills, expertise, and facilities of DOE's Office of Defense Programs to make essential contributions to the national security. None of these other organizations offer viable alternatives to the contributions of this program.

The Nuclear Materials Security and Safeguards Program also supports research and development for international safeguards and security and bilateral or multilateral exchanges under prescribed conditions consistent with or related to overall Department missions, in particular, those missions related to nuclear energy and national security. In addition, it manages a U.S. Government Program of Technical Assistance to IAEA Safeguards (POTAS) to respond to identified urgent needs of the International Atomic Energy Agency. The POTAS Program is funded by the Department of State under the Foreign Assistance Act and is coordinated with the State Department, the Arms Control and Disarmament Agency (ACDA), and the Nuclear Regulatory Commission.

The seven major interrelated objectives relating to the four goals of the Nuclear Materials Security and Safeguards Program are the following:

- Develop countermeasures to preclude malevolent access to Department of Energy facilities and the compromise of classified information, including the assurance of personnel reliability (Security Investigation Program and the management and administration of all security operations in the Washington, D.C., area). (Sections 141, 145, 161, and 229 of the Atomic Energy Act of 1954 (P.L. 83-703), as amended, Executive Order 10450, Executive Order 10865, and Executive Order 12065.)

- Conduct research and development on physical protection components and systems, as well as special nuclear material control and accountability components and systems; and provide systems implementation assistance to program organizations. It is expected that the components and systems developed will improve DOE safeguards and security in a cost-effective manner (section 127 of the Atomic Energy Act of 1954, as amended).

- Perform special nuclear material accountability operations for all Department functions (sections 31-33 and 161 of the Atomic Energy Act of 1954, as amended).

- Gain a comprehensive understanding of potential adversaries and actions, assess vulnerabilities to and consequences of malevolent acts directed against critical U.S. energy resources and Department operations, and define DOE threat deterrence and response strategies (section 161 of the Atomic Energy Act of 1954, as amended, Executive Order 11490 as amended by Executive Order 11921, and Executive Order 11953).

- Develop and test concepts, systems, and inspection strategies, in collaboration with the International Atomic Energy Agency, to facilitate effective international safeguards in support of non-proliferation commitments. This includes the U.S. offer to apply IAEA safeguards to DOE facilities according to U.S./IAEA Safeguards Agreements (Title II of Nuclear Non-Proliferation Act of 1978 (P.L. 95-242), sections 31-33 of the Atomic Energy Act of 1954, as amended).

- Collaborate with other countries to improve the effectiveness of safeguards and security systems used throughout the world (Title II of Nuclear Non-Proliferation Act of 1978).

- Conduct training, as required by the Nuclear Non-Proliferation Act of 1978, in safeguards and physical protection.

Overall, the above objectives are directed toward the management, administration, and coordination of security and safeguards for all of DOE. Table 52-1 displays objectives with corresponding accomplishments of this program for fiscal years 1978 through 1981.

Program Results

The objectives of the program have been met through implementation of the program plans and successful completion of milestones. Activities conducted are described in Table 52-1. This program benefits the Nation as a whole, with the original objectives remaining relatively unchanged since the program's inception. The technology base of components, systems, and associated data resulting from research and development is made available to other Department programs and to the private sector and, through cooperative arrangements, to other Federal agencies and foreign programs. While the ultimate goal of security and safeguards is "protection," achievement of protection cannot be measured in terms of dollars against the lack of serious malevolent threats. Estimates of total DOE budget authority applicable to security and safeguards since 1978, are as follows:

Total DOE Security and Safeguards

Fiscal Year	Total DOE Budget Authority (in millions)	Nuclear Materials Security and Safeguards' (includes Security Investigations) Portion of Budget Authority* (in millions)
1978	$210	$58.0
1979	$214	$61.3
1980	$201	$63.0
1981	$223	$67.4

*Does not include funds for Classification which will be added to the program in fiscal year 1983 and beyond.

The total Department of Energy security and safeguards budget figures above cover funding for the eight DOE programs having security and safeguards interests (including the Nuclear Materials Security and Safeguards and Security Investigations Program) as part of the Department total. That portion of the DOE total specifically for the Nuclear Materials Security and Safeguards Program (including Security Investigations) is also shown separately.

Table 52-1 displays the degree to which the objectives of this program have been met, with information concerning program performance for the past 4 fiscal years. This program operates under annual and multiyear program plans which provide information on the program's planned milestones to satisfy its goals and objectives. Table 52-2 outlines the objectives, needs, and justification for the future.

The following are significant accomplishments for major program activities during fiscal year 1978 through fiscal year 1981; other accomplishments are shown in Table 52-1.

The program redirected the limited professional security resources of the divergent Federal agencies brought into the Department of Energy (for example, the Energy Research and Development Administration (ERDA), the Federal Energy Administration, the Strategic Petroleum Reserve Office, and the Power Marketing Administrations) and revitalized a comprehensive security program for DOE. Additionally, the personnel security program policies and requirements were remodeled to meet the needs of the new Department of Energy and to accommodate the entry of an "excepted service" agency (ERDA) into the civil service "competitive" system (Executive Order 10450). Investigative requirements were realistically modified to accomplish budgetary savings on the order of $3.7 million per year. An operational security program was begun to effect improved recognition of hostile intelligence collection directed against DOE strategic and other critical resource energy activities.

Specific procedures and equipment for safeguarding fuel enrichment and reprocessing plants were developed. A lightweight, air-transportable accident-resistant container for safe and fast transport of safeguards samples was developed. Collaboration was achieved with two countries and one international organization for exchange of safeguards and physical security information. Two training courses were conducted for students from more than 20 countries in the fields of "material control and accountancy" and "physical protection of nuclear materials and facilities." Beginning in fiscal year 1980, 15 major facilities were assisted to remedy identified deficiencies using the developing base of technology on physical protection and special nuclear material control and accountability.

The program established a comprehensive series of nuclear materials directives, including OMB approval of joint DOE/NRC reporting forms for U.S. nuclear materials. The Nuclear Materials Management and Safeguard System was modified to meet the U.S./IAEA Safeguards Agreement Reporting requirement. A 2-year program was successfully implemented for the verification of U.S. nuclear materials exported. An advanced Credibility Assessment Threat Communication System for analyzing threats was developed and implemented. Bilateral collaborative efforts involving Canada and France for responding to nuclear incidents were successfully completed. Also, a program plan for handling hostage situations involving Department of Energy facilities and personnel was developed.

Projected Program Requirements

The budget enacted for fiscal year 1982 is $69.1 million. This level of funding will provide the resources required for the continuation of domestic and international security and safeguards programs and for meeting legislative objectives, departmental commitments, and responsibilities delegated through Executive orders. Continuing resources will include the upgrading of existing systems and advancing safeguards technology, and transfer of that technology domestically and internationally.

Detailed justification for fiscal year 1982 funding for Nuclear Materials Security and Safeguards is provided in the fiscal year 1982 Congressional Budget Request, Volume I, Atomic Energy Defense Activities. Major construction activities and facility operating expenses are budgeted primarily through the other seven Department of Energy programs having security and safeguards interests. The effect of a 10-percent decrease in the level of support for this program in fiscal year 1982 would result in the following activities not being accomplished:

- Planned assistance in implementation of required safeguard systems at several facilities

- Planned counterintelligence actions including technical security and audio-countermeasures support, selected operations security surveys, and essential computer security research and development efforts

- New systems for safeguards information displays, contraband detection, personnel identifiers, and equipment for guard training
- Planned security communications and instrument development and measurement activities
- Selected non-proliferation activities

The impact of a 10-percent decrease would be a significant increase in the risk to DOE facilities and the national security.

A 10-percent increase in funding for this program would support:

- Improvements in operations security with emphasis on counter-intelligence surveys, computer security operations, and audio-countermeasures
- Improvement in security force training and in personnel and training equipment
- Expert assistance directed toward resolving identified deficiencies and upgrading safeguards at existing facilities

The need for these improvements has been identified as necessary to enhance the current and future effectiveness of safeguards and security at Department of Energy facilities.

Transitional Requirements

The program supports national security objectives in the research, development, and production of special nuclear materials and nuclear weapons; activities related to other critical U.S. energy resources; and international non-proliferation commitments. In the event of funding discontinuation, the majority of functions performed would need to continue somewhere in the Federal Government.

(53) NUCLEAR WEAPONS ACTIVITIES (DP)

Program Objectives

The Department of Energy Nuclear Weapons Activities Program's goals are to develop and direct programs of research, development, testing, production, and reliability assessment of nuclear weapons; to direct the Department of Energy program for the prevention of accidental or unauthorized nuclear detonations; and to maintain liaison between the Departments of Energy and Defense on nuclear weapons matters.

Under the Atomic Energy Act of 1954 (P.L. 83-703) (particularly section 91), the Atomic Energy Commission was granted sole authority to conduct the Nation's nuclear weapons program. The Energy Reorganization Act of 1974 (P.L. 93-438) transferred this authority to the Energy Research and Development Administration, and section 301 of the Department of Energy Organization Act of 1977 (P.L. 95-91), transferred the program to the Department of Energy.

Three documents provide the basis for the Department's nuclear weapons program: the Nuclear Weapons Stockpile Memorandum (NWSM), the Underground Nuclear Test Program (UNTP), and the Nuclear Weapons Development Guidance (NWDG). NWSM is reviewed and approved annually by the President; UNTP, semiannually. NWDG is received from the Department of Defense and is advisory in nature. Table 53-1 details the program accomplishments from fiscal year 1978 through fiscal year 1981.

Following are the historical and current objectives of the Nuclear Weapons Activities Program:

- Produce and modify the weapons systems for on-schedule delivery to the stockpile and retire weapons as approved in the Nuclear Weapons Stockpile Memorandum

- Maintain the U.S. nuclear weapons stockpile in a high state of readiness and initiate production of replacement parts for selected stockpiled weapons

- Conduct research, development, and testing activities directed toward the design of new systems

- Conduct underground tests at the Nevada Test Site sponsored by the Department of Energy and the Department of Defense as directed by the UNTP under the terms of the Limited Test Ban Treaty

- Continue to restore research and development capabilities in fundamental scientific and engineering areas to ensure an adequate weapons science and technological base for the future

- o Continue an aggressive health and safety program throughout the weapons complex

- o Maintain a national emergency response capability to respond to nuclear terrorism, accidents, and incidents

- o Continue to restore and replace aged and obsolete facilities at weapons program sites

Table 53-2 summarizes the estimated outyear requirements to support program objectives currently planned for the fiscal year 1983 to fiscal year 1987 period.

The nuclear weapons program is, by law, unique to the Department and is not duplicated within either the private sector or the Federal Government, including the Department of Defense. Within DOE's defense programs, the Inertial Confinement Fusion Program is a complementary effort designated to investigate and develop the full potential of fusion energy for weapons technology and in the longer term for energy-related applications (see PAU #54, "Inertial Confinement Fusion").

Program Results

The goals and objectives established by Congress in the DOE Organization Act and by NWSM, NWDG, and UNTP were successfully achieved with a 4-year total funding level of $6,856.5 million (see Table 53-1).

- o Production and Surveillance--The Department met the delivery and retirement schedules as defined in NWSM; provided the surveillance and maintenance of the Nation's existing weapons stockpile; and continued the stockpile improvement program.

- o Research and Development--The necessary research and development activities historically have been carried out to satisfy the new weapons design requirements in NWSM and to identify new design opportunities.

- o Technology Base--At the end of fiscal year 1981, the weapons program began activities to reinvest in technology base research and development. The primary emphasis of the technology base activities is to develop ideas and concepts to meet future Defense Department requirements.

- o Testing--Nuclear weapons testing is an integral part of weapons research and development. Over the past 4 years, tests were conducted as planned and met the test objectives identified. In UNTP, tests were directed toward certifying the performance of new weapons designs, ensuring the performance of existing designs in the stockpile, developing designs for future weapon systems, and supporting technology base activities.

- o Health and Safety--The Atomic Energy Act of 1954, as amended, provides the basis for the appropriate health and safety activities within the weapons program; section 161(i)(3) authorizes DOE to prescribe such regulations or orders as necessary "to govern any activity authorized pursuant to this act . . . in order to protect health and to minimize danger to life and property."

Nuclear material is handled, transported, and stored throughout the weapons complex. Appropriate safety regulations are established and enforced at all sites. The Department of Energy has prepared environmental impact statements which are required by the National Environmental Policy Act to protect the environment from possible adverse effects of the weapons program activities. The Department participates in safety studies and concurs in safety rules for weapons in Defense Department custody, thereby ensuring that public safety interests and military operational requirements receive equal emphasis.

- Emergency Response/Preparedness--The Assistant Secretary for Defense Programs provides a technical capability to respond to nuclear terrorism, accidents, and incidents. Capabilities include the Nuclear Emergency Search Team and the Accident Response Group. Both share certain personnel and equipment, although they are organized and trained for different purposes. The Nuclear Emergency Search Team evaluates threat messages, searches for nuclear devices, diagnoses and disables such devices, and takes protective measures to mitigate danger to people and property. The Accident Response Group is trained to respond to nuclear weapons accidents of both the Departments of Energy and Defense in accordance with agreements with the Federal Emergency Management Agency and the Department of Defense.

Projected Program Requirements

The fiscal year 1982 enacted funding level is $2,734.0 million. The levels of research, development, and testing, and the production of nuclear weapons approved by the President can be sustained at this funding level.

The weapons program is increasing its activities to meet Department of Defense weapons systems requirements, to proceed with the restoration of aging facilities, and to conduct additional tests to restore the viable level of effort in technology base activities.

The projected nuclear weapons program requirements include:

- Production and Surveillance--To accomplish the production and retirement of nuclear weapons, as identified in NWSM and approved by the President (see Table 53-2).

  If funding were reduced by 10 percent, DOE would give priority to producing the weapons and to ensuring the quality of the stockpile. Reductions would be absorbed in other areas such as the restoration program. The production facilities throughout the weapons complex are aging. A restoration program begun in fiscal year 1980 was originally planned to be a 6-year program; however, it now will continue beyond fiscal year 1987. A funding reduction likely would result in delaying the completion of this program even further. With insufficient restoration funding, aging facilities deteriorate at a rate faster than they can be restored, with the result that the restoration may never be completed, ultimately necessitating construction of new facilities at a much greater cost. Unless the complex is restored, production failures are likely to occur.

A 10-percent increase in requested funding would be used to accelerate the restoration of the facilities in the weapons complex.

- Research and Development--To meet the projected Defense Department requirements in NWDG and NWSM, phase 1 (weapons concepts), phase 2 (feasibility studies), and phase 3 (development engineering), alternatives must be performed during the outyears fiscal year 1983 to fiscal year 1987 (see Table 53-2).

  A 10-percent funding reduction would result in accomplishing only that specific system design research required to meet Defense Department goals. Technology base research would be conducted only at essential levels. A 10-percent increase would ensure that research for all future systems would be continued. Research to provide a technology base to minimize technological surprise and to provide the capability to assess the nuclear weapons posture of other nations would continue.

- Testing--To meet the demands of expanding weapons technologies, an annual level of testing somewhat higher than current levels will be required (see Table 53-2).

  A 10-percent decrease in funding would not adversely affect the goals set in NWSM and UNTP. These goals would be met. Additional tests to broaden the technology base would not be conducted. A 10-percent increase in requested funding would allow additional tests essential to enhance technology base research.

Transitional Requirements

Pursuant to the Atomic Energy Act of 1954, the Department of Energy has sole statutory authority to conduct the Nation's nuclear weapons program. The nuclear weapons program is responsive to statute, congressional mandate, Executive order, and Defense Department requirements. Termination of funding would be extremely disruptive to the Nation's defense program, and legislative action would be necessary in order to assign weapons activities to another agency.

(54) INERTIAL CONFINEMENT FUSION (DP)

Program Objectives

The original objective of the inertial fusion program was stated as follows in the initial program budget authorization, the fiscal year 1976 congressional authorization for the Energy Research and Development Administration: "The objective of the laser fusion program is to determine the scientific feasibility of laser and electron beam initiated thermonuclear reactions using principles of inertial confinement." Inertial confinement fusion, as developed theoretically during the 1950's in the course of nuclear weapons research, requires strong compression of a mixture of the heavy isotopes of hydrogen to very high density before the fuel reaches the temperature required for fusion, resulting in a large energy release while the fuel is confined by its own inertia.

Extremely intense pulses of laser light or particles deposited on suitable targets permit the measurement of material properties at the very high temperatures and pressures of interest in nuclear weapons research. Measurable burn makes possible the study of some aspects of the physics of nuclear weapons in reproducible experiments in the laboratory. When the energy released becomes sufficiently large, it will be practical to simulate some important weapons effects using the neutrons, alpha particles, and X-rays resulting from fuel burn. These specific applications to the nuclear weapons research and development mission of the Department of Energy weapons laboratories have been judged to be particularly important to the ability of these laboratories to attract and retain theorists and experimentalists in areas of research related to nuclear weapons research. Most of this work is fundamental to a determination of the feasibility of high energy gain from pellet implosions, which would be necessary for inertial fusion to be used as a civilian energy source.

The development of capabilities in the nuclear weapons laboratories to accomplish these nuclear weapons physics-related activities has been authorized annually by the Joint Committee on Atomic Energy and, since fiscal year 1977, by the House and Senate Armed Services Committees, as a program in support of the military application of nuclear energy. This agency mission has been prescribed by the Atomic Energy Act of 1954 (P.L. 83-703) and the Energy Reorganization Act of 1974 (P.L. 93-438). In fiscal year 1976, Congress authorized supporting inertial fusion research in non-Government laboratories. The Department of Energy Organization Act of 1977 (P.L. 95-91) transferred "the management and implementation of the nuclear weapons program and other national security functions involving nuclear weapons research and development" to the Assistant Secretary for Defense Programs. In the Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980, Congress approved the designation of lead laboratories to coordinate Government and non-Government laboratory research as a device to more effectively use research and development funds in accomplishing the military application goals of inertial fusion.

The program objectives and detailed tasks undertaken to attain them are listed in Tables 54-1 and 54-2, along with the program accomplishments and requirements discussed in the following sections. The feasibility of inertial fusion induced by lasers or particle beams cannot be addressed by other programs. Since it is known from nuclear weapons experience that the general concept is feasible, the major uncertainties in laser or particle beam-induced fusion are the effective coupling of beam energy to very small fuel masses, the stability of imploding targets, and the most appropriate energy source technology to accomplish the objective of demonstrating high-energy gain from target implosions. Nuclear weapons operation does not address these major uncertainties, nor does the magnetic fusion approach produce conditions of fuel burn that are of interest to weapons physics research. Inertial fusion is unique among basic and applied research programs in the laboratories in its contributions to understanding some areas of weapons physics not accessible in nuclear tests and to supplementing weapons research and development activities or providing some of their benefits under conditions of limited or total testing restrictions. In addition, inertial fusion research addresses the scientific feasibility of an independent approach to virtually unlimited fusion energy. The existence of independent approaches to fusion enhances the probability of successful control of fusion energy for peaceful purposes. Potentially, inertial fusion research and development may create the scientific basis for utilizing renewable energy resources consistent with the purposes of the Department of Energy Organization Act.

Program Results

Following the demonstration of the laser in 1960, research on the development of suitable laser beams for the task of rapid compression and heating of fuel capsules began at the Lawrence Livermore National Laboratory. Progress in laser development led to interest in laser-driven fusion in other U.S. laboratories and in foreign laboratories during the 1960's. By the mid-1970's, lasers, as well as high-energy particle beam generators, had been developed capable of delivering very high energy to capsules in very short pulses, which resulted in measurable thermonuclear burn in fuel capsules. Energy yields became sufficiently large to permit measurement of target implosions and growing understanding of the complex interactions between beam and target. The major program effort was devoted to the development of suitable lasers or particle beam machines to meet the unique requirements of inertial fusion, target fabrication technology, and diagnostic instrumentation to measure unprecedented levels of density and temperature at an extremely small scale and in times of billionths of a second. Experiments utilizing these capabilities are directed toward gaining an understanding of the requirements--on beam quality and target capsule design--to achieve fuel ignition and project the required energy level for high-energy gain from targets.

At the time the Department of Energy was organized, the initial stage of research leading to feasibility demonstration had been accomplished with the demonstration of thermonuclear burn of fuel capsules using lasers as the energy source, or "driver," and verification that the energy release resulted from heating and compression of the fuel core. The number of fusion reactions observed in a single experiment has since risen by some four to five orders of magnitude. Targets have been compressed to about 100 times the density of liquid hydrogen, which is about 10,000- to 20,000-fold compression and within an order of magnitude of that required for significant thermonuclear burn. Target heating and compression have been demonstrated using both direct laser illumination and X-rays created by the conversion of laser light. Diagnosis of the energy released has revealed the phenomena dominating the complex beam-target interaction. Modeling of these experiments has led to advanced target designs that would reach high-energy gain, given enough driver energy efficiently deposited in the fuel. A major uncertainty concerning these calculations is in the beam-target interaction, which cannot be predicted with confidence over a large range of incident-energy on the target.

The strong dependence of laser light interactions on wavelength, which was projected theoretically in the early 1970's, has been demonstrated experimentally at low-beam energies. This has been accomplished through the conversion of several glass lasers to emit short wavelength light by the addition of special optical crystals. Very efficient conversion has permitted direct observation of short wavelength light interaction with targets without the necessity of developing short wavelength lasers for experimental purposes. The short wavelength laser experiments have confirmed that an important next step in the program would be to increase converted glass laser energy to the level at which one can predict with confidence the energy on target required for ignition and high gain.

A second major effort in the program has been to understand and evaluate the coupling of long wavelength laser light to targets, since the most efficient known gas laser which might be adapted to fusion applications--carbon dioxide--operates at long wavelength. The development of very short pulse, high-energy carbon dioxide lasers has made possible direct study of long wavelength light absorption, transport, and conversion in targets. Most of the energy has been found to be converted to very high-energy electrons, which preheat the target fuel rather than blow off the surrounding capsule and thus provide compressive force to the fuel, as required for significant thermonuclear burn. Appropriate target designs for long wavelength light have been designed and are being tested through experimentation.

Because of their focusing properties, very short pulse lasers can concentrate sufficient energy on very small targets to produce very high pressures and temperatures. These lasers have been applied directly, without the production of fusion energy, to experimentation with various materials to measure materials properties such as opacities and equations of state of interest in weapons design. By virtue of the very high power density obtainable with laser beams, they can also be utilized in modeling some of the physical phenomena observed as nuclear weapons effects. These specific weapons applications are being accomplished in the nuclear weapons laboratories using lasers and diagnostic tools developed in the inertial fusion program.

Pulse power generators of beams of electrons, developed originally for nuclear weapons effects studies, have been adapted to high-energy, short-pulse generation of electrons and light ions for fusion experiments.

A series of such machines has raised the power level on target to 1 to 2 terawatts and verified theoretical predictions of the deposition of electrons and light ions in target materials. The Particle Beam Fusion Accelerator brought into operation during fiscal year 1980 is expected to reach 30 to 40 terawatts on target and demonstrate one or more approaches to beam focusing that will reach a power density on target comparable to that attained with lasers. As with lasers, particle beams may be deposited directly in target materials or converted into X-rays to drive the target. Target designs have been developed for lower power density and larger focal size to be tested on the planned upgrade of the Particle Beam Fusion Accelerator.

The program objective of feasibility demonstration of laser or particle beam-driven fusion has been accomplished to the degree that experimental capabilities have been developed to cause fusion reactions in targets, permit study of the phenomena present in imploding fuel masses, and provide data on which to project the requirements for fuel ignition and sustained burn, necessary for significant applications of inertial fusion. In support of the program objective, a new experimental facility is under construction at each weapons laboratory. The facilities are as follows: ANTARES, a carbon dioxide laser facility located at Los Alamos National Scientific Laboratory; NOVA, a glass laser facility located at Lawrence Livermore National Laboratory; and the Particle Beam Fusion Accelerator (PBFA-II), a light ion beam facility located at Sandia National Laboratories in Albuquerque, New Mexico. All of these facilities will be operational by the end of fiscal year 1985. The facilities will be used to determine scaling of driver and target parameters required to achieve target ignition. Cumulative funding for the DOE program in inertial fusion (for fiscal years 1978 to 1981) totals about $684.7 million. Funding detail and important steps toward developing the experimental capability required for a fuller understanding of inertial fusion physics are listed in Table 54-1 by the approximate time of accomplishment. Table 54-2 lists anticipated needs for the program to progress during the next 5 years toward its objective of feasibility determination.

The major activities to be pursued in the 1982 to 1986 period are the completion of the next generation of high-energy, single-pulse driver facilities at the nuclear weapons laboratories: the NOVA glass laser system at Lawrence Livermore National Laboratory, the ANTARES carbon dioxide gas laser at Los Alamos National Laboratory, and the Particle Beam Fusion Accelerator upgrade at the Sandia National Laboratories. Precursor experiments to develop targets and diagnostics will be accomplished on smaller systems: two beams of the NOVA system will be assembled to test NOVA target designs starting in fiscal year 1983 as scheduled; the existing HELIOS carbon dioxide laser at Los Alamos will continue in use as a target facility; and the Particle Beam Fusion Accelerator (PBFA-I) completed at the Sandia National Laboratories in fiscal year 1980 will be brought into operation as a target facility by fiscal year 1983 as planned. The major supporting laboratories using smaller glass lasers for physics experiments will provide data on very short wavelength target interactions, on the dynamics of target implosion, and on particular physics issues that can be investigated at low-energy levels.

Projected Program Requirements

The fiscal year 1982 enacted level is $209.1 million. With sustained effort, a better understanding of target physics phenomena is expected to be gained which will allow a reliable determination of the facility size that would be necessary to achieve significant net energy gain. At a 10-percent increase in the level of support, a more aggressive program of improved driver technology and target design would be permitted. At a 10-percent decrease in the level of support, driver technology, target design, and the level of experimental effort would be reduced.

Transitional Requirements

The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.

(55) VERIFICATION AND CONTROL TECHNOLOGY (DP)

Program Objectives

The Verification and Control Technology Program encompasses a wide range of activities contributing to U.S. national defense and serving U.S. national security interests. Broad program goals have remained substantially constant since the program was initiated by the Atomic Energy Commission, continued by the Energy Research and Development Administration, and currently handled by the Department of Energy. Detailed program objectives have varied in response to national needs over the years, but there has been no major change in objectives during the DOE period, from fiscal years 1978 through 1981.

The Department of Energy is the national repository and focus of expertise in nuclear weapons science and technology, in nuclear weapons effects, and in nuclear power. The Verification and Control Technology Program seeks to bring this unique resource to bear on national problems by pursuing the following goals:

- To contribute to the development of a national capability to detect, identify, locate, and characterize nuclear explosions carried out underground, in the atmosphere, and in space, consistent with the verification requirements of existing and future treaties

- To develop and maintain a science and technology base adequate to:

  - Support DOE participation in the formulation of U.S. arms control policy

  - Support treaty negotiations

  - Provide a sound basis for treaty violation challenges by the United States and for response to challenges to the United States

  - Preclude technical surprise in detection technology or evasion techniques

- To maintain, improve, and apply the expertise of DOE laboratories to increase U.S. understanding of foreign nuclear weapons capabilities and potential in support of intelligence community efforts

- To develop, maintain, and apply nuclear-related expertise required to formulate and implement U.S. policy on export control and technology transfer

- To apply DOE expertise in energy technology and analysis to support U.S. energy policy formulation, especially international initiatives, and provide reliable information to DOE planners on foreign energy resources and technologies

Among the main objectives resulting from the program goals are to meet the requirements set for spaceborne nuclear detection sensor systems; to develop techniques and equipment for monitoring underground nuclear explosions by both seismic and nonseismic means; to demonstrate monitoring and verification techniques consistent with negotiating postures, such as the use of unattended in-country stations arranged in a regional seismic network; to provide weapons laboratories resources and expertise to analyze foreign nuclear weapons intelligence data and assist intelligence community efforts; to supply scientific and technical expertise to U.S. arms control policy-makers and negotiators; and to review, in a timely way, proposed exports of nuclear and nuclear-related materials, equipment, and technology to determine their impact on U.S. national security. Specific objectives are detailed in Tables 55-1 and 55-2.

Section 3c of the Atomic Energy Act of 1954 (P.L. 83-703), as amended, calls for "a program for Government control of the possession, use, and production of atomic energy and special nuclear material, whether owned by the Government or others, so directed as to make the maximum contribution to the common defense and security and the national welfare, and to provide continued assurance of the Government's ability to enter into and enforce agreements with nations or groups of nations for the control of special nuclear materials and atomic weapons." The Verification and Control Technology Program also responds to related requirements mandated by the Atomic Energy Act, as well as requirements either directly mandated or flowing from the Nuclear Non-Proliferation Act of 1978 (P.L. 95-242), the Export Administration Act of 1979 (P.L. 96-72), and the Arms Control and Disarmament Act of 1961 (P.L. 87-297), as amended. In addition, program activities meet requirements mandated in annual Department of Energy authorization legislation and annual authorizing legislation for the intelligence community, as well as requirements mandated in Executive Order 1203, "United States Intelligence Activities."

While this program shares objectives with programs in the Department of Defense and the intelligence community, it complements and supplements the others in moving toward the objectives and draws upon the unique skill, expertise, and facilities of DOE's Office of Defense Programs to make essential contributions to national security. Neither the private sector nor other Government agencies represent viable alternative providers of these contributions.

Program Results

The objectives of the program have been met and continue to be met by providing:

- The science, technology, and equipment base for nuclear test ban treaty verification

- o The nuclear weapon and nuclear power expertise to support intelligence analyses, arms control policy formulation, and arms control treaty negotiations

- o The nuclear weapon and nuclear power expertise required for timely review of export license applications

Specifics of program results for fiscal years 1978 through 1981, and the budgetary costs incurred are summarized in Tables 55-1 and 55-2. Cumulative obligations authority for fiscal years 1978 through 1981 was $133.3 million. On an aggregated basis, major accomplishments of the program (and its predecessors) include the following:

- o Nuclear test detection and related satellite instrumentation design and delivery schedules have been met without fail, beginning with the first VELA launched in 1963.

- o Satellite instruments have operated in orbit with extraordinary reliability. For example, instruments provided through the program have accumulated more than 1 million hours of satisfactory operation with no failures during the operational periods of the spacecraft platforms, far exceeding program targets.

- o Engineering models of an in-country unattended seismic station (the National Seismic Station) for regional seismic monitoring have been fully conceived, developed, and tested in Tennessee and Alaska on an accelerated schedule and establishment of a five-station Regional Seismic Test Network is under way. All milestones have been met.

- o This program provided most of the technical base for the negotiation of the Limited Test Ban Treaty, Threshold Test Ban Treaty, and Peaceful Nuclear Explosions Treaty, and major technical support to the U.S. negotiators since the July 1977 initiation of trilateral negotiations for a Comprehensive Test Ban Treaty.

- o Review of proposed nuclear and nuclear-related exports has kept pace with steadily mounting numbers of cases. In fiscal year 1981, about 85 percent of 7,200 cases reviewed were completed within the 30-day initial period allowed by the Export Administration Act. Most of the remaining 15 percent required referral to the Ad Hoc Subgroup on Nuclear Export Coordination, an interagency body whose Secretariat is provided by the Department of Energy under this program.

The Verification and Control Technology Program makes important contributions to the ability of other Government agencies to accomplish their missions. The Department of Defense is the most obvious beneficiary. Other direct beneficiaries include the Department of State, the Arms Control and Disarmament Agency, the Department of Commerce, and the Nuclear Regulatory Commission.

As noted earlier, the overall goals of the program have remained substantially unchanged throughout its existence; however, activities within the program have received more or less emphasis and resources in response to events and Administration policies and priorities. For example, as a consequence of the uncertainty over the cause of a Southern Hemisphere event on September 22, 1979, an effort currently is under way to improve nuclear test detection capability in the Southern Hemisphere. Similarly, as a result of arms control policy needs, DOE currently is engaged with other agencies in a major study of the possible impact of various nuclear test yield restraints on U.S. national security.

Projected Program Requirements

The enacted funding for fiscal year 1982 is $50 million. This level of effort will provide most, but not all, of the resources required to deal with growing concerns in test ban treaty verification and, more particularly, the spreading of nuclear weapons and nuclear weapons capability to nonnuclear weapon states. The effect of a 10-percent increase or decrease in the level of support for the program is discussed in a note at the bottom of Table 55-2. Detailed justification is provided in the Congressional Budget Request, Volume I, Atomic Energy Defense Activities. Major activities to be pursued are the following:

- Research, development, design, fabrication, pre-flight integration, and post-flight monitoring of nuclear test detection systems for an operational Department of Defense satellite

- Scientific and engineering research and seismic detection of underground nuclear explosions, with emphasis on regional seismology through the operation of the Regional Seismic Test Network with stations in the United States and Canada

- Studies of nuclear weapons practices and foreign nuclear fuel cycle technology to support the Intelligence Community and U.S. arms control policy-makers

- Reviews of export license applications pertaining to nuclear materials, equipment and technology, and analysis of export control and technology transfer issues

The fiscal years 1983 through 1987 program will continue the fiscal year 1982 activities cited above and enable new initiatives in the following areas:

- Southern Hemisphere nuclear detection

- Deep space nuclear detection

- Advanced sensors and sensor deployment techniques

- Advanced sample analysis

- Detection of nuclear material

Transitional Requirements

More than 95 percent of this program is carried out at the weapons laboratories. All of the program is responsive to statutes, congressional mandates, Executive orders, and the Department of Defense and the Director, Central Intelligence, requirements. An orderly termination of this program within DOE would require a 1-year notice, at essentially normal funding levels, to permit transition of those activities that must continue to management by other agencies, and possibly different arrangements for their execution. Legislative action is required to transfer to other agencies those activities assigned by statute to the Department of Energy.

(56) DEFENSE WASTE MANAGEMENT (DP)

Program Objectives

Radioactive waste is generated in the production of nuclear materials for the defense programs. The Department of Energy has the responsibility for the management of these wastes by providing for processing, storage, transportation, and disposal so that safety, environmental, and public health standards are maintained. The overall historical and current objective is to prevent adverse impacts on health, safety, and the environment by safe storage, transport, and disposal of radioactive wastes. The near-term objective is to manage all radioactive waste generated in the Department of Energy through disposal of low-level wastes by shallow land burial and interim storage of high-level and transuranic wastes in ways that are compatible with potential disposal methods. The long-term objective is to provide the necessary confinement of radioactive wastes in a manner that requires minimum reliance on future maintenance and surveillance by man; and that ensures a high degree of isolation from man's environment during the time the waste poses a potential radiation hazard. Programs leading to the terminal storage of defense waste include constructing the Waste Isolation Pilot Plant (WIPP). This facility is a research and development project to demonstrate the safe disposal of radioactive wastes from defense activities of the United States and is exempted from regulation by the Nuclear Regulatory Commission.

The initial responsibility for managing defense radioactive waste was given to the Atomic Energy Commission in section 91 of the Atomic Energy Act of 1954 (P.L. 83-703) as a function incident to the nuclear weapons program. The Department of Energy Organization Act of 1977 (P.L. 95-91) created DOE and detailed the responsibilities of the Department, which include establishing control of facilities and existing wastes at defense sites, and programs for the management, treatment, transport, and disposal of wastes. Legislation that established the mission and authorized the Waste Isolation Pilot Plant is in the Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980 (P.L. 96-164).

Interim management of high-level waste (HLW) requires operation, surveillance, and maintenance of facilities for volume reduction of waste and for interim storage of the existing 292,000 cubic meters of liquid, salt cake, and sludge in underground tanks at Richland, Washington, and Savannah River, South Carolina, and granular calcined solids in underground bins at Idaho Falls, Idaho; construction of improved (double-shell) underground storage tanks and transfer piping to eliminate continued use of single-walled and other tanks of earlier design for storage of liquid waste; and process development and facility construction to continue converting liquids to solids and making appropriate transfers to new tanks to provide improved interim storage until long-term disposal options are selected and implemented. Long-term management of nuclear wastes requires technology development, engineering studies, conceptual designs, tests, demonstrations, and evaluations as a basis for selecting site-specific alternatives consistent with the National Environmental Policy Act (NEPA) and for building associated facilities to implement them. The research and development program in progress is designed to fill the technology gaps for long-term management.

In support of the interim operations and long-term management alternatives, transportation systems are being developed. This activity consists of developing standards, data bases and testing methods, and providing logistics and economic analyses, safety and accident analyses, and a technical information center. Management of surplus defense-related Department of Energy facilities is performed in the Decontamination and Decommissioning activity. These surplus facilities must be maintained in a safe condition prior to a program to decommission them. Included are 350 facilities, most of which are located on the Hanford site at Richland, Washington, with others at New Brunswick Laboratory, New Jersey; Niagara Falls, New York; Weldon Springs, Missouri; Idaho National Engineering Laboratory, Idaho; Oak Ridge National Laboratory, Tennessee; and the Mound Facility, Ohio. The Decontamination and Decommissioning program is discussed in PAU #19, "Remedial Actions."

Technology developed in the Defense Waste Management Program is not duplicative, but complementary to the commercial program. As an example, the information and experience gained in developing technology for immobilizing defense high-level waste is being assessed in developing related technology for the commercial sector.

Major objectives and accomplishments in fiscal years 1978 through 1981 are reflected in Table 56-1. Future activities and milestones are shown in Table 56-2.

Program Results

Safe processing, containment, and storage of radioactive waste remain necessary. DOE's Defense Waste Management Program is meeting the original objective of preventing adverse impacts on health and safety even though certain activities and accomplishments originally planned for fiscal years 1978 through 1981 have not been met. The interim operations efforts provide for construction of new facilities and for upgrading of existing operations to manage the waste. The long-term management program seeks to develop, select, and implement disposal alternatives at all Department sites. In response to section 213 of the Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1982, a report will be prepared by June 30, 1983, that sets forth plans for the permanent disposal of high-level and transuranic wastes resulting from atomic energy defense activities.

The Defense Waste Management Program supports the production of nuclear materials for the defense program by managing the waste generated in the production of these materials. By maintaining safe interim operations and progressing toward implementation of the long-term management of Department wastes, potential hazards are reduced. The technology developed in this program also will be applicable to resolving commercial waste problems.

The following are major accomplishments for each activity; other accomplishments are shown in Table 56-1.

- Interim Waste Operations--At Hanford, all 149 old single-shell tanks have been deactivated. Twenty new tanks are complete, and activities are under way to stabilize and isolate the 149 old tanks. At Savannah River, 18 new waste tanks are on schedule for completion in 1982. The transfer of high-level waste from old tanks to new tanks is progressing. At Idaho, additional high-level waste storage bins are on schedule. Although the completion of the New Waste Calcining Facility was delayed because of labor and scheduling problems, it is now complete and hot operations are scheduled in 1982.

- Long-Term Waste Management--The original plan to implement long-term programs for management of high-level and transuranic wastes at all DOE sites is proceeding on a phased basis. Alternatives for high-level wastes at Savannah River have been evaluated. Evaluation of alternatives for the transuranic waste at Idaho is now under way.

- Waste Isolation Pilot Plant (WIPP)--Since 1978, this project has been repeatedly delayed by potential changes in the project's mission. In 1980, the Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act defined WIPP as a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from U.S. defense activities and programs. Shaft sinking for the site and the design validation phase of the program began in July 1981.

During the fiscal years 1978 through 1981 period, DOE has safely managed existing and newly generated waste and is proceeding to select alternatives for a long-term management of these wastes. The total cost for the fiscal years 1978 through 1981 period was approximately $1.2 billion.

<u>Projected Program Requirements</u>

In fiscal year 1982, $368.4 million is budgeted for the Defense Waste Management Program. A major portion of these funds is required for the management of waste operations. Funding also is provided for technology development and design in the long-term management program activities, including the Defense Waste Processing Facility at Savannah River to immobilize high-level waste and the Waste Isolation Pilot Plant.

Outyear funding levels will reflect requirements for continued waste operation at Department of Energy sites involving processing and storage or disposal of DOE radioactive waste; for a long-term technology program including the Defense Waste Processing Facility and the Transuranic Waste Treatment Facility; and for the Waste Isolation Pilot Plant.

A reduction of 10 percent (or about $37 million) from the $368.4 million budget level would delay completion of the Defense Waste Processing Facility and the Waste Isolation Pilot Plant by at least 1 year each and would increase the total estimated costs of these projects by roughly $100 million and $70 million, respectively.

An increase of 10 percent in the budget would allow key programmatic activities to proceed at a faster pace and would save about $50 million. The transfer of high-level waste to new tanks at Savannah River, the stabilization and isolation of old high-level waste tanks at Hanford, and the upgrade of severely deteriorated general support/landlord facilities at Hanford would all be accomplished 1 year earlier.

Transitional Requirements

The Defense Nuclear Waste Management Program is required for the continued protection of the environment and the public's health and safety. Discontinuation of this program would require amendment of the previously referenced legislative authority.

D.

REVIEW OF
GENERAL SCIENCE PROGRAMS

OVERVIEW

The Department's High Energy and Nuclear Physics Program makes up nearly 90 percent of all such research conducted in the United States. Carried out as a national trust, the program differs from other departmental research in that the research itself and the knowledge it produces are the overriding goals. More specifically, its historical and current concern is to attain a comprehensive understanding of the fundamental structure and constituents of matter and the laws of nature that underlie all physical processes. High energy and nuclear physics research deals with the resolution of questions that could lead to a fundamental change in our thinking about the physical world, as did the work of Maxwell in electricity and Einstein in physics.

The Department of Energy and its predecessor agencies have established a sound reputation for effectively managing and operating the large high-technology facilities and activities that characterize high energy and nuclear physics research. Under this management, U.S programs in high energy and nuclear physics achieved an enviable reputation for high productivity and world leadership. The current Administration is committed to maintaining this leadership.

(57) HIGH ENERGY AND NUCLEAR PHYSICS (ER)

Program Objectives

There is a fundamental difference between the High Energy and Nuclear Physics (HENP) Program and the Department's other research and development efforts. HENP is devoted to basic research and its mission is the acquisition of new knowledge. Specifically, the program seeks a deeper understanding of the constituents and behavior of matter and energy at the most fundamental levels. Long seen as a natural part of energy research, the program explores the kind of fundamental issues that, when resolved, could restructure our thinking about the physical world, as did the discoveries of Maxwell in electricity and Einstein in modern physics. Tables 57-1 and 57-2 depict historical and current program objectives.

High energy and nuclear physics experiments center on particle accelerator and colliding beam facilities designed to permit examination of the interactions of subnuclear particles and atomic nuclei. The High Energy Physics Program focuses on the basic structure of the particles and on the forces that determine the behavior of matter and energy at the most fundamental level--their creation and annihilation, their detailed properties, and their transformations. The particles include the familiar protons, neutrons, electrons, and photons, in addition to less familiar neutrinos and muons. Also included are particles called quarks, which are the constituents of protons, neutrons, and other particles. This research program endeavors to uncover the fundamental physical laws that are revealed at extremely high energies.

Nuclear physics concentrates on the interactions, structure, and other fundamental characteristics of atomic nuclei. Many nuclear studies are conducted by observing the interactions of nuclear probes with nuclei in bulk matter. The probes may be other nuclei, nucleons, electrons, or subnuclear particles. The nuclear physics research also includes the areas of nuclear theory, heavy ion physics, and medium energy physics. Experimental nuclear research at lower energies retains strong ties with current applications of nuclear energy, and it is conducted as part of the separate program in basic energy sciences.

Basic research in the fields of high energy and nuclear physics was chartered by the Atomic Energy Act of 1946 (P.L. 79-585). Chapter 4, as amended, of the Atomic Energy Act of 1954 (P.L. 83-703) directed the Atomic Energy Commission "to insure the continued conduct of research and development and training activities . . . to assist in the acquisition of an ever-expanding fund of theoretical and practical knowledge in such fields." The program was transferred to the Energy Research and Development Administration by Title I of the Energy Reorganization Act of 1974 (P.L. 93-438), and then to the Department of Energy by section 301 of the Department of Energy Organization Act of 1977 (P.L. 95-91).

The Department acts as executive agent for high energy physics and nuclear physics research and conducts these activities as national trusts. About 90 percent of the Federal support for high energy physics and 85 percent of the support for nuclear physics is provided by DOE; the National Science Foundation is the other major source of Federal support for this type of research. The program is not duplicated in the private or public sectors.

The continuing goal of these national trust programs is to achieve a comprehensive understanding of the fundamental structure and constituents of matter, the basic forces in nature, and the laws of nature that underlie all physical processes involving transformations of matter and energy. The historical and current objectives set in pursuit of this goal are identical and are listed in Table 57-1. They reflect the more general congressional goal of expanding the knowledge base in these fields. The primary objective is obtaining new knowledge and understanding of the fundamental nature of matter and energy. Other objectives include the following:

- To maintain U.S. world leadership in high energy and nuclear physics research

- To support theoretical and experimental research in high energy and nuclear physics

- To construct, operate, and maintain the national accelerators and colliding beams and detection and analysis systems required to carry out research

- To carry out research and development in new accelerator and detector technologies needed for continuing progress in high energy and nuclear physics

- To maintain an adequate source of trained scientific manpower by providing appropriate support to universities and laboratories

- To identify practical applications of research in physics and transfer the results to the appropriate scientific or technological discipline

Short of transferring HENP as an entity to another Federal agency, there is no viable alternative for accomplishing its goals and objectives. They can be reasonably pursued only through major accelerator and other experimental facilities. Because of the long-term nature of the research and the fact that its contributions to technology are unpredictable and often indirect, the private sector has little incentive to provide the necessary support.

Although Federal support of high energy and nuclear physics research could be shifted to another Federal agency, unless the program, personnel, and supporting facilities were transferred in toto, severe disruptions would occur and the Government would receive neither economic nor management benefits. In fact, costs would probably increase because the new supporting agency would have to build up its own capabilities to manage the large laboratory programs that would replace those already existing within the Department of Energy.

Program Results

The intellectual content of high energy and nuclear physics research has attracted some of the Nation's finest scientists. They have recently developed a theory providing a unified description of the electromagnetic force and the weak nuclear force, a feat comparable to Maxwell's unification of electricity and magnetism in 1865. In addition, they have advanced understanding of the observed predominance of matter over antimatter in the universe and have established and experimentally verified a fundamental quark-structure theory that has made order out of the "zoo" of subnuclear particles.

The full importance of discoveries in these long-range fields of basic research may not be realized for years; far-reaching implications of the accomplishments listed in Table 57-1 will become clear only with further study and the perspective of time. The technological advancement that occurs from such research is virtually a guaranteed bonus.

One of the bonuses for science and industry is the technology of superconducting materials and devices. This is expected to have a dramatic impact on U.S. electric power supply, transmission, and usage. Also, there is a long history of HENP contributions to radio frequency power generation, materials analysis, and medicine (including new methods of treating cancer). Recently, synchrotron light from particle accelerators opened up totally new research capabilities in chemistry, solid state physics, biology, and industrial applications. Free electron lasers, driven by particle accelerators, promise new capabilities for enhanced laser power and tunability. Radiation processing, which was born from this science, has many exciting new applications ranging from the manufacture of heat-shrinkable electrical insulation to the sterilization of wastes and the preservation of food.

The health and safety risks associated with the High Energy and Nuclear Physics Program include those routinely encountered and accepted in everyday living by the vast majority of the public, as well as low risks associated with controlled use of accelerators and research quantities of radioactive material. Risks are reduced and dealt with in a responsible manner.

Projected Program Requirements

As shown in Table 57-2, the high energy physics and nuclear physics research budget for fiscal year 1982 is $484.3 million. At this level of funding, the major accelerator facilities will operate at a level substantially lower than that of 1981, and four smaller accelerator facilities will be phased out.

The construction and efficient operation of large, complex accelerator facilities are essential to the execution of frontier research in high energy and nuclear physics. The capabilities of these facilities determine which experiments can be done and thus determine the pace and quality of the entire scientific field. Construction of new facilities or significant upgrading of existing facilities requires typically 3 to 6 years. In addition, the necessary prototype accelerator physics research requires anywhere from 3 to 5 years. Long-range planning is absolutely essential to ensure that the rate at which new facilities are brought on line is properly phased with the rate at which existing facilities lose their scientific effectiveness.

Considerable efforts have been made to maintain stable program funding and level of effort in accordance with the High Energy and Nuclear Physics Program long-range plans. However, in recent years, monetary inflation and the need for fiscal restraint in Federal funding have forced reductions in the scope of the national programs in order to focus available resources on the highest priority facilities and research programs. An increase in funding over current levels would increase operating time for selected experimental and accelerator facilities and extend and permit additional research and development for new concepts and capabilities critical to the program's future. Funding at levels reduced from those of fiscal year 1982 would substantially decrease ongoing research activity and would sacrifice future capabilities. U.S. world leadership in high energy and nuclear physics would be severely challenged.

Transitional Requirements

Discontinuation of the High Energy and Nuclear Physics Program would dismantle the Nation's present and future capabilities in basic nuclear and subnuclear research. The U.S. position of international leadership in these fields would change to one of dependence upon other countries for fundamental knowledge about matter and energy. If the program were to be discontinued, significant costs would be incurred in the termination of existing major facilities, laboratory programs, user groups, and construction projects. Transfer of management of these programs to any other agency would require extreme care to minimize disruption of these research activities.

E.

REVIEW OF
THE MANAGEMENT
OF THE DEPARTMENT

MANAGEMENT OF THE DEPARTMENT

OVERVIEW

The Department of Energy provides a range of central and field management and associated staff activities in support of programs dealing with energy research, development, and applications; energy emergency preparedness; defense; and general sciences. The goals and objectives of these activities have remained unchanged since the creation of the Department in 1977.

Two program analysis units were developed to cover the management of the Department: Departmental Administration and International Programs. Within the former, two subprograms are addressed: Management and Administration, and Corporate Staff Functions. Three subelements make up Management and Administration, namely Management and Support, Technical Information Services, and Program Management and Project Support. Four subelements constitute Corporate Staff Functions: Congressional, Intergovernmental, and Public Affairs; Inspector General; General Counsel; and Policy, Planning, and Analysis.

Because of the high visibility of international activities and obligations, an entire program analysis unit is devoted solely to International Programs. The Department of Energy Organization Act of 1977 (P.L. 95-91) gave the Department responsibilities in developing and implementing international energy policies. Emphasis has been and continues to be placed on improving U.S. access to world energy markets and on reducing the Nation's vulnerability to supply disruptions.

Under the current Administration, the Department continues, at reduced funding and staffing levels, to respond to the historical goals of establishing and implementing international energy policy consistent with domestic energy policy and U.S. foreign policy. In the area of cooperative bilateral and multilateral research and development, emphasis is shifting to long-term, high-risk programs with large potential payoffs.

(58) DEPARTMENTAL ADMINISTRATION (MA)

Program Objectives

Departmental Administration encompasses the basic operation and support of a large headquarters and field organization. This program analysis unit is composed of two subprograms: Management and Administration, and Corporate Staff Functions.

Management and Administration comprises three subelements: Management and Support, Technical Information Services, and Program Management and Project Support.

Responsibilities charged to Management and Administration range from ensuring the Department's financial integrity and the protection of its business interests to the smooth functioning of management activities and coordinating the flow of correspondence. Duties include serving as the source of management policies and procedures and as the central repository for all official documents and key departmental actions and decisions; providing administrative services, procurement, automatic data processing, and communications; handling guidance and overview of contractor salary and benefit programs; managing technical and loan assistance to minority businesses and educational institutions; administering all equal opportunity activities of the Department; operating a large technical information program; and overseeing program management and project support.

The functions and activities of the Department, both at headquarters and in the field, involve numerous personnel. With the creation of the Department of Energy in October 1977, a new personnel program was established to accommodate approximately 22,000 employees inherited from eight Federal agencies. The transfer was complicated by the fact that more than 8,000 employees came from an organization that was excepted from the career civil service and thus had no prior experience with the competitive procedures required by that system. All 22,000 positions were subsequently reviewed to ensure that assigned duties and responsibilities were consistent with the new organization and that the positions were properly classified for pay purposes.

Most functions within Management and Support were provided for by the Department of Energy Organization Act of 1977 (P.L. 95-91). Certain specific requirements were derived from other legislation. For example, section 641 of the National Energy Conservation Policy Act of 1978 (P.L. 95-619) created the Office of Minority Economic Impact to assist minority groups and businesses affected by national energy policies and regulations. The Office of Small and Disadvantaged Business Utilization was established governmentwide by the 1978 Amendments to the Small Business Act and the Small Business Investment Act of 1958 (P.L. 95-507) to advocate the utilization of small and small disadvantaged business concerns for the Department's contractual requirements.

Management and Support objectives have remained constant since the Department's inception, though from time to time new policies were imposed by other Government agencies in response to executive or legislative branch initiatives that somewhat modified the goals of the organization. Two examples are cited: Executive Order 12320, which seeks to achieve an increase in the participation of historically black colleges and universities in federally sponsored programs; and the requirement to establish a merit pay system for midlevel managers and supervisors.

The goal of the Department's centralized Technical Information Services was and is to promote the effective use of scientific and technical energy-related information. The Atomic Energy Act of 1954 (P.L. 83-703) calls for the "dissemination of scientific and technical information . . . to provide for the interchange of ideas and criticism which is essential to scientific and industrial progress and public understanding and to enlarge the fund of technical information . . ." (42 U.S.C. 7141(a)). When the Department of Energy was established, this objective was included as an objective of the DOE Act (42 U.S.C. 7112(5)).

The Department's Technical Information Center provides a number of technical information services in such a manner as to avoid costly duplication of effort. These services include the integrated collection, processing, and management of both classified and unclassified results from the Department's multibillion dollar per year research and development program; and the maintenance and management of a computerized data base that represents a comprehensive reference to worldwide research and development. The results of research and development are managed separately from the gathering, analysis, and dissemination of resource, supply, and demand data, which is the responsibility of the Energy Information Administration.

Program Management and Project Support involves two major objectives: program management for the In-House Energy Management Program which consists of studies, energy conservation retrofits, and fuel conversion for departmental facilities; and management and support of major systems acquisitions and projects for the Department (including independent cost estimates and other construction project assessments for Under Secretarial key decisions) and policy and implementation procedures for the management of real property acquisition and disposal, construction, site development, site facility utilization, and utilities contract support.

Legislation affecting the In-House Energy Management Program includes the National Energy Conservation Policy Act of 1978, the Energy Policy and Conservation Act of 1975 (P.L. 94-163), and the Powerplant and Industrial Fuel Use Act of 1978 (P.L. 95-620). In addition, Executive Order 12003 of July 20, 1973, requires retrofits of Government buildings, a 10-year energy management plan for them, and reductions in building consumption of fuel oil and natural gas.

Specific project management objectives include the issuance of policies and procedures to ensure the acquisition and management of systems, equipment, utilities, and real property, and services that maximize cost effectiveness and reliability as well as improve the Department of Energy project management system. Major objectives established for the In-House Energy Management Program are to reduce total energy consumption per square foot by 20 percent in Department of Energy buildings by fiscal year 1985 from a fiscal year 1975 base, to reduce Department of Energy fuel oil consumption by 30 percent by fiscal year 1985 from the same base, to retrofit Department of Energy buildings to minimize life cycle energy costs by 1990, to construct new facilities that are 45 percent more energy efficient than the fiscal year 1975 inventory, and to convert major Department heating plants from fuel oil and natural gas to coal or to other less critical fuels by the year 2000. The program includes surveys and studies of existing facilities used to develop energy-saving retrofit projects, a gasohol initiative, employee awareness, ridesharing, solar energy and other demonstrations at Department of Energy facilities, conservation in new building design, and driver training for Department and operating contractor personnel.

Corporate Staff Functions, the second subprogram, comprises four subelements: Congressional, Intergovernmental, and Public Affairs; Inspector General; General Counsel; and Policy, Planning, and Analysis. These functions incorporate a variety of basic staff responsibilities--relations with Congress, state and local governments, and the public; the promotion of efficiency and economy, the detection of fraud and abuse; the provision of legal services; and the development of energy plans and policies.

The Department of Energy Organization Act is the major authorizing legislation for Congressional, Intergovernmental, and Public Affairs. Its responsibilities include direct liaison with Congress and the development and administration of policies and programs that provide direct liaison with external groups. The Department is required by section 102 of the act to promote the interests of consumers and create a program of public awareness of energy programs; to provide for cooperation and coordination of Federal, state, and local governments in the development of national energy policies and programs; to foster and ensure competition within the energy industry; and to maintain close liaison with Congress and the public. Section 401 of the Intergovernmental Cooperation Act of 1968 (P.L. 90-577) calls for full state and local government participation in the development of programs and the promulgation of Federal regulations with significant intergovernmental impact; and section 604 of the 1980 bill to authorize appropriations for certain insular areas of the United States (P.L. 96-597) requires the preparation of comprehensive energy plans for U.S. territories with emphasis on indigenous renewable resources.

The Department of Energy Organization Act established the office and responsibilities of the Inspector General within the Department of Energy. These responsibilities include audit and investigative activities relating to the promotion of economy and efficiency in the administration of programs and operations of the Department and the prevention or detection of fraud or abuse in those activities. Sections 305, 304, and 307 of the Supplemental Appropriations and Rescission Act of 1980 (P.L. 96-304) require the Inspector General to submit to Congress information concerning unresolved audits, overdue debts to the Government, and consultant service contractual arrangements. Executive Order 12036 defines the role of the office in intelligence oversight activities. Executive Order 12301 established the President's Council on Integrity and Efficiency, of which the Inspector General is a member. The Council investigates fraud and waste in

Government programs. Cases of fraud and abuse identified by the Inspector General are referred to the Department of Justice for prosecution. The Inspector General has the responsibility to oversee all departmental operations and programs.

The Office of the General Counsel, in accordance with section 202(b) of the Department of Energy Organization Act, provides legal support to administrative and program offices, conducts administrative and judicial litigation, and provides legal advice and support for enforcement, regulatory oversight, and related activities.

The General Counsel appears on behalf of the Department before Federal and state agencies and is responsible for the coordination and clearance of testimony presented by Department officials before congressional committees. The General Counsel also is responsible for ensuring consistency and legal sufficiency of departmental regulations and proposed legislation affecting the Department of Energy, for administering and monitoring standards of conduct requirements, for conducting the Department's patents program, and for providing legal advice on Department intelligence activities.

The final element of Corporate Staff Functions is Policy, Planning, and Analysis. Its responsibilities are varied and include providing the Secretary of Energy with an objective policy analysis and evaluation capability, coordinating policy analyses conducted within the Department and the executive branch, and carrying out studies mandated by Congress. The Policy, Planning, and Analysis element was established in response to the Department of Energy Organization Act; its goals have remained unchanged since the Department was established in October 1977. Those goals are to identify major energy policy issues; to create a foundation for energy policy and programs through analysis and evaluation; and to institutionalize the process of policy guidance and program development throughout the Department.

Funding shown in Tables 58-1 and 58-2 reflects all elements of the Departmental Administration program analysis unit, including the field functions performed by the operations offices.

Program Results

Management and Support fulfilled its functions during the past 4 years by providing assistance to and support of the Department as a whole. It organized the reduction in the number of buildings occupied by Department of Energy headquarters personnel since 1977 from 22 to 11 and established, during the same period, a centralized administrative support system for the entire Department. The public was affected by Department of Energy operations in such areas as procurement solicitations, personnel recruitment, and increased participation by minorities in energy programs. The public was also assisted by the Department's freedom of information staff, which provided access to information at the rate of approximately 200 requests per month.

During the past 4 years, Technical Information Services has been an integral part of the energy research and development process. The information managed by this service is required before, during, and at the conclusion of projects to provide for the successful conduct of the Department's research and development programs. Without this system, considerable research and development would be duplicated or delayed, and program decisions would have to be made without benefit of the most up-to-date and comprehensive information available.

Each year since October 1977, the Technical Information Center has provided the Department of Energy and its contractors with information on results from more than 150,000 new energy research and development documents produced worldwide. The cumulative cost of research contained in this system exceeds $135 billion. At a time when the economy requires reductions in Federal budgets, this technical information system represents the most economical source of new technology that the United States has at its disposal.

Program Management and Project Support affects the project management of current major system acquisitions and construction projects totaling more than $44 billion, the real estate management of more than 3 million acres of land and more than 500,000 square feet of leased space, the facilities management of 92 million feet of Department-owned facilities, and the annual consumption by the Department of 14.5 million barrels of oil equivalent. The requirements of the Office of Management and Budget Circular A-109 regarding major systems acquisitions have been and are being met as a result of policy and procedure directives issued under this subelement. The procedures have resulted in improved, streamlined, and cost-effective management of programs and projects conducted as part of the Department's mission.

During the 4-year review period, the Department complied with requirements established by the Architectural Barriers Act of 1968 (P.L. 90-480) and Title 41, Federal Property Management Regulations, subpart 101-19.9, which prohibits barriers to Government facilities that may be encountered by the physically handicapped. As a result of in-house management activities through fiscal year 1980, the Department of Energy reduced building energy consumption by 11.7 percent per square foot and fuel oil consumption by approximately 40 percent. The Department is undertaking fuel conversions at seven of its major heating plants. Studies are completed or under way at seven additional plants, and another four studies are planned that would bring the fuel conversion effort to its conclusion.

Between fiscal years 1977 and 1980, 228 retrofit projects were funded at a cost of $51.4 million. When complete, they are expected to save 5.8 trillion Btu's annually, or 7 percent of the Department's total energy consumption. Studies and surveys are continuing to develop retrofit projects for future years' funding with paybacks in the 3-to-4-year range. The Department also developed a 10-year energy management plan for its buildings and its research and weapons production process. In addition, policy and implementing procedures were established for project management, real estate management, site development and utilization, as well as internal fuel use and selection by the Department of Energy.

Within Corporate Staff Functions, the Office of Congressional, Intergovernmental, and Public Affairs implemented outreach programs that benefited Congress; other Federal agencies; state, tribal, and local governments; consumers; the media; and the energy industry. All original objectives are being met. Changes have been made in program focus following the 1977-1981 review period. In the Public Affairs area, emphasis shifted away from conceiving and implementing advocacy communications campaigns to activities that ensure a balanced public education program reflecting the new Administration's energy policy, and to coordinating communications efforts among departmental program offices. These achievements have ensured clarity and consistency in information disseminated by the Department and have provided opportunities for participation in energy policy and decision-making.

Audits, inspections, and investigations conducted by the Inspector General during the 4-year review period resulted in substantial savings or cost avoidances. Inspector General activities benefit the Department in particular and the Federal Government in general.

Since the establishment of the Department, the General Counsel has fulfilled its objective to provide sustained legal support to the direct benefit of all Department offices and program activities (except those of the Federal Energy Regulatory Commission, which is represented by its own counsel). Changes in the Department's functions and roles resulted in diminished need for legal support for certain activities because of the decontrol of petroleum products.

All original objectives of the Policy, Planning, and Analysis element were met during the 1977-1981 review period. Specific Policy, Planning, and Analysis accomplishments include implementation of a Planning, Programming, and Budgeting System, which resulted in annual and 5-year resource allocation plans for all operating programs; completion of a number of special policy analyses, typified by the Oil Vulnerability Study; and preparation of a variety of mandated reports, including the biennial national energy policy plans.

The number of beneficiaries of efforts undertaken by the Policy, Planning, and Analysis element cannot be quantified, nor is it possible to estimate the effects of its activities on the economy. The policy options that are the subject of analyses by this element have broad implications for health, safety, environment, and economic interests, as well as the concerns of nearly every segment of society.

Transitional Requirements

An orderly termination of activities grouped under Management and Administration would require several months to more than 2 years to complete, depending on the element considered. Most of the organization was established by the Department of Energy Organization Act; therefore, it would be necessary to enact new statutes to transfer those functions to other Government agencies. All departmental records would have to be transferred to the General Services Administration for retention, in accordance with the Federal Records Act, 44 U.S.C., chapter 33.

Were Technical Information Services to be terminated, the unique national information resource it represents would no longer be available to support U.S. economic and industrial progress and national security. This resource represents the results of more than 35 years and $50 billion worth of federally funded nuclear, defense, and basic energy sciences research and development and the comparable results of foreign research and development investments. In addition, if the centralized information program were discontinued, the official U.S. commitment to the International Atomic Energy Agency Nuclear Information Accord would have to be terminated. Accordingly, this information should be transferred to a central repository.

Administrative actions would be needed to allow the smooth and efficient transfer to the General Services Administration or other agency of real and personal property acquired by the Department. Because of ongoing contracts, 2 years probably would be required to effect this transfer. Project management functions would have to be continued by a successor agency or transferred to Department of Energy field organizations. Additional administrative actions allowing decentralized implementation of the Office of Management and Budget Circular A-76 (Policies for Acquiring Commercial or Industrial Products and Services Needed by Government) and Circular A-95 (Evaluation, Review, and Coordination of Federal and Federally Assisted Programs and Projects) would be required to transfer these functions to field components. The decentralization of Circular A-109 activities (Major Systems Acquisitions) would require at least 2 years. Additionally, completed contract closeouts will take approximately 3 to 4 years for cost-type contracts, primarily because of audit requirements.

Transitional requirements for Corporate Staff Functions parallel those for Management and Administration. Discontinuation of the Office of Congressional, Intergovernmental, and Public Affairs would require the termination of all contractual support in the areas of public affairs, energy industry competition, and consumer activities. Departmental programs, even if transferred to other new or existing agencies, would require legal counsel familiar with those programs. In addition, responsibility for the Department's present litigation efforts should be transferred to the Department of Justice in order to ensure that the Government's position regarding each case is preserved. Were major departmental functions transferred to existing agencies or new agencies, they would require audits, inspections, and presumably, investigations. Accordingly, the resources of the existing Office of Inspector General should either be transferred intact to one agency or divided among a number of agencies that would receive the elements of a dismantled Department of Energy. Discontinuation of Policy, Planning, and Analysis would require termination of personnel, cancellation of contracts, or transfer of personnel and contractual obligations to another Federal agency.

(59) INTERNATIONAL PROGRAMS (IA)

Program Objectives

The Department of Energy Organization Act of 1977 (P.L. 95-91) requires the Department to develop and implement international energy policy consistent with domestic energy and U.S. foreign policy and to provide independent technical advice to the President on international energy-related matters.

Specific international responsibilities also are set by other legislation. The Atomic Energy Act of 1954 (P.L. 83-703), as amended, and the Nuclear Non-Proliferation Act of 1978 (P.L. 95-242) assign the Department specific responsibilities in the areas of international nuclear cooperation and non-proliferation, including participation and concurrence in negotiating international agreements for cooperation and principal responsibility for concluding "subsequent arrangements" under those international agreements. DOE administers section 252 of the Energy Policy and Conservation Act of 1975 (P.L. 94-163), which provides an antitrust defense for U.S. oil company participation in the International Energy Program (oil supply) of the International Energy Agency (IEA). Pursuant to section III of the Natural Gas Act of 1938 (P.L. 75-690) as amended by the Department of Energy Organization Act, the Department determines that proposed natural gas imports and exports are not inconsistent with the public interest based on criteria that include energy security. In the area of export control, the Department has a policy advisory opinion role in nuclear exports (Nuclear Non-Proliferation Act of 1978, section 301) and in oil and gas production equipment and technology exports (Export Administration Act of 1969, section 5(a)). In non-nuclear research and development, the Energy Reorganization Act of 1974 (P.L. 93-438) and the Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473) establish mandates for international cooperative programs. The Department also has intelligence responsibilities assigned by Executive Order 12036 of 1978, which requires the Secretary to make the Department's technical and analytical expertise available to the Director of Central Intelligence and directs Department of Energy representation on the National Foreign Intelligence Board.

The primary goal of the Department's international activities has been to improve U.S. access to world energy markets and to reduce U.S. vulnerability to supply disruptions. Other major objectives have included development and implementation of U.S. policy on nuclear cooperation and non-proliferation and development and implementation of a program of cooperation for technical research and development. Specific accomplishments for fiscal years 1978, 1979, 1980, and 1981, as well as particulars of current program objectives, are summarized in Tables 59-1 and 59-2.

Program Results

During the past 4 years, the Department attempted to develop policies to reduce U.S. dependence on imported oil, lessen U.S. vulnerability to international oil supply disruptions, and increase supplies of alternative energy sources such as natural gas, coal, nuclear, and synthetics. These policies were pursued at annual economic summits and in the International Energy Agency. For example, the Department proposed the Presidential commitment at the 1978 Bonn Economic Summit to decontrol oil prices, and supported the IEA's measures to deal with major supply disruptions caused by the Iranian revolution and the Iran-Iraq war. Recent policies emphasize market-oriented responses to speed both the short- and long-term adjustments. During the same period, the Department also enhanced U.S. access to foreign natural gas supplies, notably from Mexico and Canada.

The Department's nuclear activities contributed to minimizing the spread of nuclear weapons and to creating a stable environment for the peaceful use of nuclear energy. This was done with the Department of State through the negotiation of new or amended agreements for cooperation in the civil use of nuclear energy with other nations and the conclusion of numerous "subsequent arrangements" under those agreements. Subsequent arrangements include approvals of contracts for the sale of special nuclear materials and U.S. enrichment services to foreign nations; participation in reviews of export licenses for equipment, reactors, and materials; and approvals of retransfers by foreign governments of U.S.-origin nuclear materials, including retransfers involving the reprocessing of spent fuel. The Department of Energy continued bilateral and multilateral technical exchanges in a wide variety of nuclear-related fields under the auspices of the International Atomic Energy Agency and the Nuclear Energy Agency of the Organization for Economic Cooperation and Development. The Department also contributed significantly to the development and implementation of the Administration's non-proliferation policy announced by President Reagan on July 16, 1981. This policy is based upon the realization that, if nuclear energy is to reach its full potential as an alternative to imported oil, effective international arrangements must be structured to minimize the spread of nuclear weapons.

The Department's technical international cooperative activities have accelerated technical progress, stretched budget and personnel resources by task and cost sharing, advanced foreign policy objectives, and provided exposure for U.S. industry that may enhance trade prospects.

Over the past 4 years, the Department of Energy increased its technical collaboration bilaterally and within IEA. At the end of fiscal year 1981, there were 103 formal cooperation agreements under which more than 270 projects are under way with one or more foreign partners (both governmental and industrial). About two-thirds of these agreements are bilateral, with the balance being multilateral, mostly within the IEA program. These projects span the full range of technology areas in the DOE domestic program and range from information and personnel exchanges to large, jointly funded projects.

With policy guidance from the Department of State, the Department of Energy's Country Energy Assessments Program provided assistance to the governments of Egypt, Peru, Portugal, the Republic of Korea, and Argentina to analyze and assess their energy needs and resources, to develop alternatives to the continued importation of oil, and to develop energy planning capabilities. This program was terminated at the end of fiscal year 1981.

Projected Program Requirements

In fiscal year 1982, $4.9 million is budgeted for International Affairs. At a 10-percent reduction in the level of effort, it would be necessary to decrease analytical efforts to the barest minimum and to cut back the technical cooperation program and Department-wide program support. At a 10-percent increase in the level of effort, analytical capabilities, including the intelligence area, could be broadened to provide additional perspective.

Transitional Requirements

The general aspects of international energy policy development and implementation could be transferred to other program areas or to other Federal departments in the event of funding discontinuation. The Department has no legislative recommendations to ameliorate disruption should funding for this program be discontinued. If funding were discontinued, the Department would employ its existing authorities to minimize disruption associated with program termination.