REPORT BY THE

Comptroller General

OF THE UNITED STATES

Fossil Energy Research, Development, And Demonstration: Opportunities For Change

The Department of Energy lacks some of the tools necessary to properly manage its fossil energy research, development, and demonstration program. Specifically, the Department needs to develop.

--A system of formal program priorities to allocate limited resources among different fossil energy technologies and among alternative approaches within these technologies.

--Program and project cost objectives for all fossil energy technologies.

--Specific evaluation criteria for determining process advancement.

The Department's Fossil Demonstration Plants Program also needs to be changed to better achieve early commercialization of fossil energy technologies.

This report was requested by the Chairman, Subcommittee on Energy and Power, House Committee on Interstate and Foreign Commerce.

EMD-78-57

SEPTEMBER 18, 1978

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-178205

The Honorable John D. Dingell
Chairman, Subcommittee on
Energy and Power
Committee on Interstate
and Foreign Commerce
House of Representatives

Dear Mr. Chairman:

This report discusses opportunities for change in the Department of Energy's approach for developing and ultimately commercializing fossil energy technologies. It is the second of two reports in response to your requests concerning the Department of Energy's Fossil Demonstration Plants Program.

The report focuses primarily on the Department of Energy's efforts to demonstrate six of the seven fossil energy technologies and identifies changes which could be made to better achieve program goals. In addition, we noted that there were some areas where the management of the overall fossil energy research, development, and demonstration program could be improved to better assure the successful commercialization of emerging fossil energy technologies.

Our first report entitled "First Federal Attempt to Demonstrate A Synthetic Fossil Energy Technology--A Failure," was issued on August 17, 1977 (EMD-77-59).

Sincerely yours,

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT TO THE SUBCOMMITTEE ON ENERGY AND POWER COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE HOUSE OF REPRESENTATIVES

FOSSIL ENERGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAM: OPPORTUNITIES FOR CHANGE

D I G E S T

Since 1973, the Federal Government has counted on developing and commercializing fossil energy technologies--such as coal gasification and liquefaction--to help reduce the Nation's increasing dependence on foreign energy.

Research, development, and demonstration funding for seven fossil energy technologies has increased from $58.4 million in fiscal year 1973 to $656.9 million in 1978--an increase of over 1,000 percent. Much of this money is being directed towards efforts to demonstrate that these techniques will be commercially viable.

Because the technical demonstration phase is the final--and perhaps most important --step before commercializing any fossil energy technology, GAO reviewed efforts by what is now the Department of Energy to demonstrate six of the seven fossil energy technologies to determine whether changes could be made to better achieve program goals.

KEY CONCLUSIONS

At the time of GAO's review in 1977, the Department lacked some of the tools necessary to properly manage fossil energy research, development, and demonstration programs. The Department has since acted to correct many of the problems GAO identified but more needs to be done to improve the management of and planning for the overall fossil energy research, development, and demonstration program.

In addition, GAO identified several changes that should be made to the Department's Fossil Demonstration Plants Program. These

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concern how the Department selects processes to be demonstrated, determines the size of the plants needed to obtain the required commercialization data, and funds the projects.

OVERALL PROGRAM MANAGEMENT AND PLANNING IMPROVEMENTS

At the time of GAO's review, the Department had not developed

--a formal system of priorities for all technologies by which to initiate and develop the most promising approaches;

--detailed cost and performance milestones to judge project and program progress, costs and problems to determine how best to proceed; or

--criteria for determining when a project is ready for the next phase of development. (See p. 18.)

Since the completion of GAO's review work, the Department began several significant actions which should help resolve many of the problems summarized above. Department officials told GAO that they were completing a study of how the marketplace could be expected to adopt emerging technologies. They said that this study is being used for establishing program priorities.

However, GAO found that a formal system of priorities has not been adopted for all technologies and that the study does not compare individual processes against a set of predetermined criteria, ranked or weighted in accordance with their importance in meeting program goals. (See p. 22.)

In addition, Department officials said that they are developing plans for each individual fossil energy technology program and project. These plans include detailed performance and decision points, but do not include detailed cost milestones for developing economically competitive fossil energy systems. (See p. 22.)

A formal system of priorities, as well as detailed cost objectives, would give the Congress a better basis for evaluating the adequacy of required funding levels of the fossil program or for funding alternative approaches. In addition, such a system could place outside organizations--such as other Federal and State agencies and private industry--in a better position to initiate proposals to meet program needs. (See p. 19.)

The Department also has not developed specific evaluation criteria for determining when fossil energy technologies or projects have achieved a level of performance to justify advancement to the next phase of development and/or commercialization. (See p. 21.)

To improve Department management and planning efforts, the Secretary, Department of Energy should develop and include as part of its overall and/or individual program and project plans:

--A system of formal program priorities to allocate limited resources among different fossil energy technologies and among alternative approaches within each. To make visible the bases for establishing priorities, this system should be supported by comparative studies, based on a set of predetermined criteria, ranked or weighted according to their importance in meeting program goals.

--Program and project cost objectives for all fossil energy technologies. These should specify target costs and dates by which those targets are expected to be met.

--Specific evaluation criteria for determining process advancement.

Improvements to the fossil demonstration program

The Department of Energy has been:

--Issuing requests for proposals and relying on industry to propose processes for consideration. A better procedure would be to establish selection criteria, evaluate alternative processes in detail against that criteria, and then select the best processes for demonstration. (See p. 27.)

--Either issuing contracts for demonstration plants which are not large enough to obtain the needed commercialization data or considering issuing contracts for plants which are larger than necessary to meet project objectives. GAO concluded that the agency should determine beforehand the size of the plant required to achieve the objectives. (See p. 28.)

--Requiring a rigid 50-50 cost-sharing policy with industry which has resulted in at least one technically superior process being eliminated from consideration because of industry's unwillingness to accept added risk. GAO concluded that the Agency's cost-sharing policy should be based on the special circumstances and risks associated with each project. (See p. 31.)

--Fully funding the design phase of project development and cost sharing with industry in the construction and operation of demonstration plants. GAO concluded that cost sharing should be required from project conception thereby giving industry added incentive to achieve the best design at the lowest cost. (See p. 33.)

To improve the Agency's Fossil Demonstration Plants Program, GAO recommends that the Secretary, Department of Energy:

--Establish specific criteria for evaluating and selecting processes for demonstration. These criteria should consider the contribution that each process can make in meeting the Nation's energy goals, total cost and timing of commercializing the process, and the incremental cost of producing energy from the process and the means by which that cost would be assimilated by the economy.

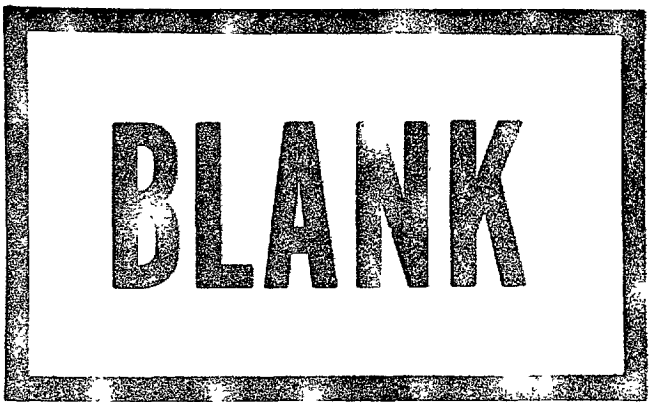
--Evaluate in detail all potential processes within each fossil energy technology and, based on the selection criteria discussed above, select the best processes for demonstration. The selected processes and their timetables for development, as well as the criteria used to select them, should be included in the Department's overall research, development, and demonstration program plan.

--Change the approach in specifying the size of the demonstration plants needed to obtain the necessary commercialization information by determining beforehand the size of the plant needed to achieve program and/or project objectives and basing the agency's requests for proposals on that determination.

--Change the cost-sharing policy to provide more flexibility in achieving program and/or project goals. This should be done by varying the cost-sharing amount for each process depending on the priority assigned to the process and the relative risks involved in constructing and operating a demonstration plant, and requiring cost sharing with industry from the beginning of the project while, at the same time, allowing industry to work with the Department in making decisions on the project's future.

AGENCY COMMENTS AND GAO EVALUATION

In a July 6, 1978, letter commenting on this report (see appendix I), the Department agreed with all but one of GAO's recommendations and said it is taking or plans to take action to implement them. It disagreed with GAO's recommendation about changing the approach in specifying the size of the demonstration plants needed for the demonstration program. GAO reemphasizes that a more logical approach to choosing demonstration projects would be to make a conscious and informed decision on the optimum size required before issuing a request for proposal.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ABBREVIATIONS

ERDA	Energy Research and Development Administration
DOE	Department of Energy
GAO	General Accounting Office

CHAPTER 1

INTRODUCTION

Most of the energy used in the United States comes from oil and gas, supplies of which are limited and projected to decline rapidly. The United States imported about 9 million barrels of oil a day in the early months of 1977--about half of the total oil it consumed. The administration's National Energy Plan predicts that imports could rise to 12 to 16 million barrels of oil a day by 1985 if action is not taken. Furthermore, the plan estimates that the oil exporting countries may not be able to fill worldwide demand through the 1980s, and the Energy Research and Development Administration (ERDA) 1/, projected that during the 15 years preceding the year 2000 the Nation's most critical energy problem is expected to be the liquid fuels gap.

The administration's plan seeks to reduce oil imports to 6 million barrels a day by 1985. In a July 1977 report on the plan 2/, we said that, unless energy demand is reduced, achieving this goal is unlikely; instead imports could be as high as 10.3 million barrels a day even if the plan were implemented as proposed.

The natural gas situation may be even more critical as evidenced by the shortage experienced during the severe winter of 1976-77. Natural gas meets about 27 percent of the Nation's energy needs while constituting only about 4 percent of the domestic energy reserves. Natural gas companies have curtailed supplies to low priority customers, and, in some cases, such curtailments appear to be in the offing for high priority customers. Furthermore, as our July 1977 report showed, the administration's plan overstated natural gas production by about 10 percent.

At the same time, the Nation's supply of coal and oil shale is large. Estimated recoverable coal reserves could last more than 300 years at the present rate of consumption and estimated shale resources contain 1,800 billion barrels

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1/At the time of our review, the Federal Government's fossil energy research and development program was administered by ERDA. Effective October 1, 1977, this responsibility was transferred to the newly created Department of Energy.

2/"An Evaluation of the National Energy Plan" (EMD-77-48, 7/25/77)

of oil, about one-third of which are considered recoverable. Thus, a potential exists for meeting domestic energy needs through the development and increased use of these resources.

Increased use of coal is a cornerstone of the National Energy Plan. Since the oil embargo of 1973, the Federal Government has counted on developing and commercializing fossil energy technologies--such as coal gasification and liquefaction--to help decrease this Nation's dependence on foreign energy. Estimates of the amount of energy these technologies will be able to contribute have been reexamined and in a number of cases revised projections of impacts were anticipated to be lower. Also, there are a number of technical, environmental, socioeconomic, legal, and financial problems to be resolved before many of these technologies can be commercialized.

FOSSIL ENERGY TECHNOLOGIES AND FUNDING

The Department of Energy (DOE) is the focal point for Federal efforts to resolve the problems associated with commercializing new fossil energy technologies. The major thrust of DOE's program is aimed at researching, developing, and demonstrating seven broad fossil energy technologies:

--Coal liquefaction where coal is converted to liquid fuel for boilers, the transportation industry, chemical feedstocks, etc.

--High-Btu 1/ coal gasification where coal is converted to gas having about 950 to 1,000 Btu's a cubic foot as a substitute for natural or pipeline gas.

--Low- and medium-Btu coal gasification where coal is converted to gas having between 100 and 500 Btu's a cubic foot to be used in conventional boilers, as chemical feedstocks, or other industrial applications.

--Oil shale conversion processes where crude oil is extracted from shale deposits.

--Fluidized-bed combustion processes where coal is burned directly in a more efficient and environmentally acceptable way than the current methods of burning coal

1/A Btu, or British Thermal Unit, is the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

to produce electricity. This process relies on removing sulfur and other undesirable emissions during the combustion process rather than using less efficient stack gas scrubbers.

--Magnetohydrodynamics, another process for directly burning coal in a more efficient and environmentally acceptable manner, functions by burning coal to produce a hot, electrically conductive gas or liquid which interacts with a magnetic field to generate electricity.

--Enhanced oil and gas recovery where efforts are being made to increase oil output from producing reservoirs and to produce gas from types of formations which are not currently major sources of gas.

The following table summarizes Federal funding for fossil energy research, development, and demonstration for fiscal year 1973 through 1978.

FOSSIL ENERGY, RESEARCH, DEVELOPMENT, AND DEMONSTRATION FUNDING LEVELS - FISCAL YEARS 1973 THROUGH 1978 (note c)

(budget authority in millions)

Technology	1973	1974	1975	1976	1977 (Estimate)	1978
Liquefaction	$10.4	$ 45.5	$ 94.7	$ 97.9	$ 73.0	$113.6
High-Btu Gasification	25.2	33.3	59.8	53.4	44.0	51.2
Low- and Medium-Btu Gasification	3.0	22.1	50.0	24.5	33.0	73.9
Oil Shale and In-situ Technology	2.5	3.2	11.4	21.4	31.0	41.5
Fluidized-bed Combustion	0.5	15.5	35.9	46.1	51.9	53.2
Magnetohydrodynamics	0	7.5	14.3	33.5	40.0	50.0
Enhanced Oil and Gas Recovery	3.1	8.7	28.2	43.3	43.2	76.7
Demonstration plants (note a)	0	0	13.0	60.9	100.3	125.9
Other (note b)	13.7	4.8	27.4	45.4	66.8	70.9
Total	$58.4	$140.6	$334.7	$426.4	$483.2	$656.9

a/Includes funds for demonstrating the seven technologies which cannot be completely broken down by technology.

b/Includes funds for advanced power systems, modifying and adding to DOE's energy research centers, other miscellaneous operating and capital equipment expenses and prior year adjustments.

c/Excludes transition quarter between fiscal year 1976 and 1977.

As the table shows, Government funding for researching, developing, and demonstrating fossil energy technologies has increased by over 1,000 percent since 1973.

GAO EFFORTS IN FOSSIL ENERGY RESEARCH AND DEVELOPMENT

We have issued a number of reports on Federal efforts to research, develop, and demonstrate new fossil energy technologies. We concluded in these reports that:

--Processes to produce synthetic fuels are commercially available but are not competitive with current prices for conventional oil and gas.

--Loan guarantees for commercial size plants to demonstrate synthetic fuels technologies should not be provided at this point in time.

--If ERDA's enhanced oil and gas recovery program is to contribute considerably to increasing energy supply, a well-defined program management plan is essential. ERDA subsequently developed a plan for its enhanced oil recovery program.

--ERDA's first attempt at demonstrating a synthetic fossil energy technology by converting coal to a clean burning liquid fuel has been a failure.

In addition, in an August 10, 1976, report entitled "An Evaluation of Proposed Federal Assistance for Financing Commercialization of Emerging Energy Technologies" (EMD-76-10), we discussed criteria for making the right choices among energy technologies. We said that three factors should be considered:

--The contribution that each technology can make in meeting the Nation's energy needs within a specified time frame either through reducing demand or increasing supply.

--The total cost of making the technology commercial, including costs of plant construction, costs of alleviating adverse socioeconomic impacts caused by the energy development, and costs of providing price supports or further subsidies.

--The price at which energy produced by the technology would have to be sold and the means by which the price would be assimilated by the economy.

We also said that the decision to use Federal incentives to assist in the commercialization of energy technologies and the determination of which incentives would be most appropriate required interrelated analysis of at least three factors.

--The technology's state of development. Is the technology developed to the extent that it can be deployed on a broad basis?

--The technology's economic feasibility. Will the energy produced as a result of deploying the technology be economically competitive with competing energy sources?

--The target group whose actions will be influenced. Are they large industrial firms or diverse and widely dispersed groups such as homeowners?

These three factors should aid in deciding the most appropriate financial or other Government incentive to stimulate a particular energy technology.

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This report is the second of two reports initiated at the request of the Chairman, Subcommittee on Energy and Power, House Committee on Interstate and Foreign Commerce. The first report, issued on August 17, 1977, discussed the failure of the first Federal attempt to demonstrate a synthetic fossil energy technology.

In this review, we focused on DOE's attempts to demonstrate six of the seven fossil energy technologies. We did not review DOE's management of the enhanced oil and gas recovery demonstration program because we reported on that program in January 1977. We concentrated our efforts on the technical demonstration program because the demonstration phase is the final, and perhaps most important, step before commercializing an emerging energy technology.

Although the focus was on DOE's administration of its fossil demonstration program, we also noted that there were some areas where the management of the overall fossil energy research, development, and demonstration program could be improved to better assure the successful commercialization of these emerging technologies.

The following chapters

--provide a perspective of how research and development projects progress through various stages towards

eventual commercialization and discuss the status of DOE's demonstration efforts;

--discuss areas where ERDA's management of its overall fossil energy research and development program could be improved; and

--discuss changes in DOE's Fossil Demonstration Plants Program which could be made to help achieve more timely commercialization of these emerging energy technologies.

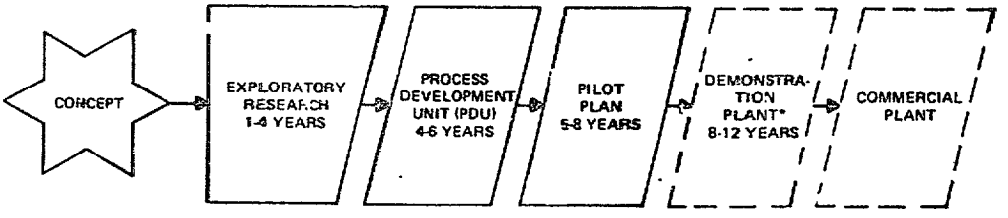
CHAPTER 2

PERSPECTIVE

A fossil energy technology or process must pass through several phases before it achieves eventual commercialization. This evolutionary process--from project conception to commercialization--normally requires from 15 to 20 years. The following sections discuss the process, the types of information that must be obtained, and the status of those technologies which DOE is demonstrating or plans to demonstrate in the near future.

PROCESS EVOLUTION

According to DOE, research, development, demonstration, and commercialization projects generally pass through five basic stages after project conception. The following illustration depicts the development process and the approximate time generally required for each phase.



If a process is proven viable during exploratory research it progresses to process development where key performance variables are tested using small-scale models. The process development unit generally uses only the minimum amount of materials necessary to test process feasibility in an attempt to

--establish the technical feasibility of the process;

--acquire basic physical, chemical, and engineering data needed to evaluate the process; and

--develop the design data needed to allow further scale-up to the pilot plant phase.

With the pilot plant, which generally operates for 3 years or less and produces enough end product for testing and refinement, DOE attempts to

--determine whether the process works with commercial-type (not commercial-size) components 1/;

--test and evaluate the critical parameters of scale-up;

--acquire engineering data needed to design a larger demonstration or near-commercial-size plant; and

--estimate the economics of a commercial-size plant.

In theory, only those technologies proven technically feasible in earlier phases are selected for technical demonstration. This, the last step before commercialization, is intended to

--demonstrate and validate the economic, environmental, and productive capacity of a near-commercial plant using commercial-size components; and

--minimize risks in accelerating industrial implementation.

According to DOE, this step can be skipped if the pilot plant is large enough to obtain the necessary information for commercialization.

DOE has a Government-industry cost-sharing strategy by which industry funds one-third of the construction and operation costs for pilot plants and one-half for demonstration plants. Initial research stages, as well as pilot and demonstration plant design, are fully funded by DOE.

Once demonstrated, the project should be ready for commercialization. However, a commercial demonstration plant, with three to five times the production capacity of demonstration plants, may be needed to resolve commercial investment uncertainties, set industry standards, and stimulate industry construction and operation of subsequent commercial plants. The Assistant Secretary for Resource Applications of DOE is formulating detailed plans on how best to commercialize the technology.

1/The primary difference between commercial-type and commercial-size components is one of size. Commercial-size components are scaled up versions of commercial-type equipment and would be of a size equivalent to equipment that could be used in a full-size commercial plant.

STATUS OF TECHNOLOGY DEMONSTRATION

DOE is demonstrating or plans to demonstrate various processes within five of the six technologies included in our review. DOE does not have any near-term plan to demonstrate magnetohydrodynamics which is currently in the process development phase. The following sections discuss the status of DOE's efforts.

Coal liquefaction

There are basically two groups of liquefaction processes; the first generation, which includes those processes that were or are now commercially available, and the second generation, which includes those processes being developed, but not yet used commercially. DOE expects that these second generation processes, once successfully developed, could reduce the cost of synthetic oil by 15 percent.

Although some first generation liquefaction processes are now commercially available, they are not competitive with the present price of conventional oil. For example, the price of oil from liquefaction processes is estimated by DOE to be from $20 to $25 or more a barrel compared to the current price of about $14 a barrel for imported oil.

Although certain technical problems need to be resolved, the economic problems (making the technology competitive) and financial considerations (being able to obtain the necessary financing) are the biggest stumbling blocks to commercializing first generation liquefaction technologies.

Because first generation technologies are commercially available (though not financially competitive) DOE is concentrating all of its fossil energy liquefaction demonstration efforts on second generation technologies.

DOE's liquefaction demonstration program

DOE's first liquefaction demonstration project was a failure. However, they do plan to fund the design work for two additional demonstration plants. On January 17, 1975, the Department of the Interior awarded Coalcon Company--a joint venture between Chemical Construction Corporation and Union Carbide Corporation--a $237 million contract to design, construct, and operate a clean boiler fuel liquefaction demonstration plant. ERDA assumed responsibility for the project on January 19, 1975, the date of its formation and terminated the project on June 15, 1977.

In August 17, 1977, report 1/ we noted that the project was plagued by technical and managerial problems from the beginning; failed in its initial phase despite a $10 million (211 percent) cost overrun and a 14-1/2 month schedule slippage; and was terminated on June 15, 1977.

Although DOE currently does not have any liquefaction demonstration projects, it has been authorized fiscal year 1978 funding to begin design work for two solvent refined coal demonstration plants. In these processes, coal is converted to clean boiler fuels by using a solvent which acts as the agent which tranfers hydrogen to the coal to promote liquefaction. Depending on the process, the boiler fuel can be in a solid or liquid form. Funds for the plants have not yet been appropriated.

Coal-gasification

In the coal gasification process, the coal is fed into a high-temperature vessel, called a gasifier, into which steam and either air or oxygen are injected. Chemical reactions occur and a mixture of gases, including carbon monoxide, hydrogen, and methane, are produced. These gases are cooled, and undesirable components, such as carbon dioxide and sulphur, are removed.

The gas produced at this point is low-Btu gas if produced with air, and medium-Btu gas if produced with oxygen. Low-Btu gas has a heat content of under 150 Btu's a cubic foot and medium-Btu gas has 150-500 Btu's a cubic foot. Low-Btu gas cannot be economically transported over long distances by pipeline--the transportation cost per Btu is too high to be competitive. It is valuable, however, as a fuel supply for onsite electrical power generation plants or industrial processes using gas-fired furnaces located near the conversion plant.

Medium-Btu gas has several advantages over low-Btu gas. For example, utilities can convert from oil and natural gas to medium-Btu gas much more easily and with less cost than converting to low-Btu gas. Low- and medium-Btu gas plants are in commercial use today, mostly in Europe, some of them based on technology developed about 40 years ago.

1/Report to the Chairman, Subcommittee on Energy and Power, House Committee on Interstate and Foreign Commerce, entitled "First Federal Attempt to Demonstrate a Synthetic Fossil Energy Technology--A Failure" (EMD-77-59).

Medium-Btu gas can be upgraded to a high-Btu gas through a reaction between its hydrogen and carbon monoxide, referred to as methanation. This high-Btu synthetic gas is a substitute for natural gas.

As with liquefaction, there are first and second generation coal gasification processes. Several companies have announced plans in recent years to build commercial-size, first generation, gasification plants, primarily using a high-Btu process from Europe called the Lurgi process. Industry officials told us, however, that because of the large amounts of capital required to construct a commercial plant (possibly in excess of $1 billion) and the relatively small size of the companies proposing to build these plants, lending institutions are reluctant to loan the needed funds for technologies which have not been used commercially. As a result, many of these organizations are advocating the use of Government incentives--mainly loan guarantees--to enable them to obtain these funds.

In addition, uncertainty as to the price that can be charged for this more expensive gas (about $4.00 for a million Btu's as compared to about $1.90 for interstate gas) presents another obstacle to commercialization. The industry generally advocates the use of so-called rolled-in, average pricing, as opposed to incremental pricing, where the consumer actually using the product would pay the full price of producing and transporting the synthetic gas. The Federal Energy Regulatory Commission has not yet decided what pricing mechanism will be allowed.

The regulatory process also presents another obstacle to the construction of commercial gasification plants. Industry officials told us that companies wishing to proceed with plans to build these plants face a time-consuming process of obtaining numerous permits and licenses on the local, State, and Federal levels.

Some second generation gasification processes have proceeded to the demonstration phase. The status of DOE's efforts to demonstrate high-, medium-, and low-Btu processes are discussed below.

DOE high-Btu gasification demonstration program

ERDA awarded two contracts in May and June 1977 for designing, constructing, and operating high-Btu plants using second generation processes. The first contract in the amount of $370 million was made with the Conoco Coal Development Company (a subsidiary of the Continental Oil Company) for a

3,800 ton of coal a day plant expected to be located in Noble County, Ohio. The second contract, for $334 million, is with the Illinois Coal Gasification Group, for a 2,200 ton of coal a day plant expected to be located in Perry County, Illinois. Currently, however, DOE has authority to construct only one high-Btu gasification demonstration plant and plans to choose the best process at the end of the design phase and to allow that contractor to proceed with plant construction and operation. If both processes are determined to be worthy of demonstration, DOE officials plan to request authority to construct an additional plant. The design phase is to be fully funded by DOE, while the remaining phases are to be cost shared on a 50-50 basis with the selected contractor.

Although only one contractor may be selected to proceed to the construction phase, DOE has contracted with both contractors for all three phases with the option of terminating the contract at the end of any phase. The milestones for completing each phase are shown below:

Phase	Number of months to complete	Estimated completion date
Design	20	October 1978
Construction	34	October 1981
Operation	42	August 1984
Total	96	

DOE's low- and medium-Btu gasification demonstration program

Low- and medium-Btu gas are used basically for electric power generation by utilities and industrial and small-scale business applications (for example, brick companies). DOE has projects designed to demonstrate the conversion of low- or medium-Btu gas for each of these uses. It has awarded contracts to two companies to design, construct, and operate demonstration plants for industrial users. The first contract for $320 million was awarded to W.R. Grace on August 26, 1977. The second contract for $180 million was awarded to Memphis Light, Gas, and Water Division on August 30, 1977. As in the case with the high-Btu demonstration projects, DOE plans to choose the best process at the end of the design phase and allow that contractor to proceed with plant construction and operation.

DOE has also awarded a contract to design, construct, and operate a demonstration plant for small-scale users. This contract was awarded to Erie Mining Company for $47.4 million on October 19, 1977.

The following tables show DOE's timetable for completing the design, construction, and operation of the industrial and small-scale projects. At the time of our review, a timetable for a utility plant project had not been developed. DOE officials told us that funds had been authorized for the project but a contract had not been awarded nor had a decision been made on whether one or two contracts would be awarded for the design phase of the project. No date for the decision has been set.

INDUSTRIAL PROJECT

MEMPHIS:

Phase	Number of months to complete	Estimated completion date
Design	20	May 1979
Construction	32	January 1982
Operation	20	September 1983
Total	72	

GRACE:

Phase	Number of months to complete	Estimated completion date
Design	21	June 1979
Construction	39	September 1982
Operation	27	December 1984
Total	87	

SMALL-SCALE PROJECT

ERIE:

Phase	Number of months to complete	Estimated completion date
Design	15	January 1979
Construction	24	January 1981
Operation	29	June 1984
Total	68	

Oil shale conversion

There are two basic processes for extracting oil from shale: surface retorting--where the shale is mined and the oil is extracted in large furnaces called retorts--and in-situ retorting--where the shale is heated while in the ground and the oil is extracted.

Although several surface retorting pilot plants have been operated by private companies, no demonstration or commercial surface or in-situ oil shale plants are operating in the United States today. Commercial oil shale plants, particularly above ground plants, require large amounts of capital (perhaps in excess of $1 billion), and industry is uncertain about the price that must be obtained to be economical (estimated to be anywhere from $10 to $30 a barrel). Other constraints to oil shale commercialization may include adverse environmental impacts, unavailability of shale lands, and high technical risk.

DOE's oil shale demonstration program

Although ERDA planned to award a contract for a surface retort demonstration plant in late 1977, a DOE official told us that, because pilot surface retorting plants have been operated by private industry, DOE considers it to be an existing technology being sufficiently developed by industry. Thus, DOE does not have any plans to seek funds to demonstrate any advanced surface retorting technologies until 1979.

DOE has awarded contracts to four companies for in-situ retorting shale oil tests. DOE plans to complete these demonstration efforts by 1981-82.

Fluidized-bed combustion

In fluidized-bed combustion, air is blown into a boiler causing the solid particles in the boiler, usually inert ash and limestone or dolomite, to become suspended in the upward current of air. Sized and crushed coal is added to this bed and is burned very rapidly. The heat released during the burning is transferred to the particles and then, in turn, to boiler tubes containing water. The steam from this generates electricity. DOE hopes this system will burn all types of coal, char, and coal wastes in a much more environmentally acceptable manner than current methods of direct combustion.

The concept of fluidized-beds has been used for many years in the chemical industry, but its use in the generation of steam with sulfur removal is a relatively new concept.

Development of the technology is now progressing to the demonstration plant stage. The major constraint to be overcome is the reliability of the process.

DOE's fluidized-bed demonstration program

The Congress has given DOE the authority to construct a fluidized-bed boiler demonstration plant. A 30 megawatt pilot plant has been constructed to provide data for the demonstration phase and, according to agency officials, 1,000 hours of continuous operation are needed to develop any conclusive data. DOE expects to obtain the needed data by 1979.

Also, a series of industrial demonstrations of atmospheric fluidized-bed combustion technology have been initiated with industry.

CHAPTER 3

NEED FOR IMPROVEMENTS IN OVERALL PROGRAM MANAGEMENT

Our review of DOE's fossil energy demonstration program indicated that the Department lacked some of the tools necessary to properly manage its overall fossil energy research, development, and demonstration programs. Specifically, DOE had developed broad management plans but had not developed (1) a formal system of priorities by which to initiate and develop the most promising approaches, (2) detailed cost and performance milestones and decision points by which to judge project and/or program progress, costs, and problems, and to determine how best to proceed, and (3) criteria for determining when a project is ready for the next phase of development. DOE has since taken or initiated actions to correct many of these problems. Our findings, DOE corrective actions, and our views on additional actions that should be taken are discussed in the following sections.

INITIAL FOSSIL ENERGY PLANNING EFFORTS

In developing the seven fossil energy technologies, DOE and its predecessor, ERDA, had developed a number of individual program plans at the time of our review. ERDA issued fossil energy research and development documents for fiscal years 1977 and 1978 describing its overall fossil energy research program and the technologies being developed. These documents discussed the status of each technology and provided very general milestones for initiating or completing certain research and development steps through 1982. ERDA had also developed very broad national energy plans in 1975, 1976, and 1977, which included its fossil energy efforts.

In conjunction with these plans, ERDA initiated a Program Approval System in 1975. The Program Approval Documents described the major resources for each research and development program during a 1-year period, and the general schedules and milestones for completing major phases of the projects and for evaluating the results. Program Approval Documents for fiscal year 1977 were issued for the oil shale, magnetohydrodynamics, enhanced oil and gas extraction, coal conversion (including coal liquefaction and high- and low-Btu gasification), and coal utilization (including fluidized-bed combustion) programs. DOE did not develop any such documents for fiscal year 1978.

In addition, ERDA released a management plan for its enhanced oil recovery program in February 1977. This plan discusses the major issues facing the program, the strategy for carrying out the program, the criteria used to evaluate and select processes, and the priority assigned to each of the 21 subprograms.

With the exception of the enhanced oil recovery plan --which is specific--all of the Department's plans set forth a very broad and general strategy and milestones for researching, developing, and demonstrating each technology. The plans, however, did not provide an adequate strategy for achieving eventual commercialization of the best technologies and processes, nor did they provide DOE management, the Congress, or private industry with (1) a formal system of priorities by which to initiate and develop the most promising approaches; (2) detailed cost and performance milestones and decision points by which to judge project and/or program progress, costs, and problems, and to determine how best to proceed; and (3) criteria for determining when a project is ready to progress to the next phase of development.

PRIORITY SYSTEM NEEDED TO ASSURE PROGRAM EFFECTIVENESS

Because DOE has not developed a formal priority system for allocating resources to each of the fossil energy technologies, the funding of the various fossil energy technologies has changed over the past few years. Initially, funding emphasis was placed primarily on the early development of a substitute for natural gas--high-Btu gasification. As these projects reached the pilot plant stage, the emphasis changed in 1974 to the development of coal liquefaction technologies. According to DOE, the emphasis is currently focusing on more advanced technologies involving coal gasification as well as enhanced recovery of oil and natural gas. Taken as a whole, DOE's fossil energy programs have been evolving over the past several years with significant shifts in funding.

The changing emphasis on different technologies has occurred because of an absence of a formal priority system for DOE's allocation of resources to each of the fossil energy technologies. To effectively use available funds, DOE's research and development efforts should be directed towards the fossil energy technologies and projects that have the greatest potential. A priority system provides the basis for selecting the most promising technologies and approaches for further development.

According to DOE officials, fossil energy priorities were established through the normal budgetary cycle with each line

division responsible for defending its programs. The managers in each division assigned priorities to projects which they believed had the greatest chance for commercialization based upon such factors as economics, technical feasibility, project risk, and potential marketability of the end products. The assistant secretary decided on the funding request based on the presentation made by each division.

The system established within the enhanced oil recovery program, on the other hand, provided a direct contrast to the procedures followed in other fossil energy programs. For example, in the enhanced oil program plan, 21 candidate subprograms were assigned priorities by DOE on the basis of eight major performance criteria weighted in accordance with their relative importance. According to DOE officials, these priorities were used as a basis for making funding requests. We did not evaluate that program to determine if projects selected for demonstration were based on the plan.

Several DOE officials said they lacked formal guidance and/or criteria for establishing priorities. The factors considered important by the divisions in establishing priorities were subjectively developed and considered, but they did not document how or the extent to which these factors were considered in establishing priorities. Thus, without such information, we could not determine weight assigned or the relative importance given to each factor--except for the enhanced oil recovery programs.

With the exception of the enhanced oil recovery program, DOE had not made comparative analyses of alternative approaches to determine priorities within fossil energy technologies. A study was made by an ERDA contractor to determine the proper mix of technologies for demonstration based primarily on cost and risk but this study was issued during the first quarter of calendar year 1977--after ERDA had decided which technologies to demonstrate.

COST AND PERFORMANCE OBJECTIVES NEEDED TO EVALUATE PROGRESS

The priorities assigned to each of the fossil energy technologies and/or approaches need to be reevaluated as research, development, and demonstration work progresses. To measure progress towards DOE's goal of commercializing new fossil energy technologies in the near- and mid-term, program plans should establish target cost limits for producing energy from each technology, including target dates for achieving these costs, and identify tasks which are clearly related to these cost and performance objectives.

Although DOE may have established cost and performance objectives in the contracts for individual projects, it had not established performance criteria for commercial acceptability, or cost and performance milestones for measuring progress towards achieving that goal in any of its individual program plans, except for enhanced oil recovery. All of the other individual plans established broad target dates for completing certain steps--such as pilot plant design, construction, and testing--but did not establish any cost or performance milestones. Without cost and performance goals and milestones, the target dates established did not demonstrate whether the fossil technologies would evolve into economically competitive fossil energy systems.

CRITERIA NEEDED TO JUDGE PROCESS ADVANCEMENT

In addition to the need for detailed cost and performance objectives, DOE needs to establish and follow specific evaluation criteria for determining when fossil energy technologies or projects have achieved a level of performance to justify advancement to the next phase of development and/or commercialization. Such criteria should also be used to evaluate unsolicited proposals received from industry. Without them, technologies may enter phases of development--such as demonstration --before identifying and resolving all of the problems and obtaining the necessary data, thus increasing the risk of failure. Such a situation occurred in ERDA's attempt to demonstrate a coal liquefaction technology with Coalcon Company. In an August 1977 report 1/, we said that this project failed, in part, because it had entered the demonstration phase before all of the necessary research and development work had been completed.

The need for evaluation criteria was heightened at the time of our review because several organizations were responsible for deciding the status of technologies and the advancement of technologies from one phase to another. Complicating this situation was the fact that a number of organizations both inside and outside of Government--such as national laboratories, Energy Research Centers, and private industry--are conducting various fossil energy research, development, and

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1/Report to the Chairman, Subcommittee on Energy and Power, House Committee on Interstate and Foreign Commerce, entitled "First Federal Attempt to Demonstrate a Synthetic Fossil Energy Technology--A Failure" (EMD-77-59, August 17, 1977).

demonstration projects. Conceivably, DOE may decide to fund some of these projects and will need criteria for deciding where to place these projects in the development process.

DOE officials told us that they do not have any established criteria for making such decisions but rely on their technical expertise and experience.

AGENCY ACTIONS

DOE has since taken or initiated several actions which should help resolve many of the problems discussed above.

DOE does not have a single overall comprehensive program plan for the fossil energy research, development, and demonstration program, but it has numerous studies and program documents which have been issued or initiated since our review was completed. Individual program and project plans are being developed which include many of the recommended tools.

For example, in early 1977, ERDA initiated a study called the Market Oriented Program Planning Study (MOPPS). In the past, ERDA's planning strategy had been primarily concerned with developing as many technologies as possible to exploit the various energy resources. The purpose of the MOPPS study was to provide a basis for prioritizing ERDA's research and development efforts by analyzing how the marketplace could be expected to adopt emerging technologies. This study, however, does not compare individual processes against a set of predetermined criteria, ranked or weighted in accordance with their importance in meeting program goals.

In addition to the MOPPS study, DOE officials said the Fossil Energy Research and Development Program documents and DOE's budget justification also reveal fossil energy program priorities.

Since our review, DOE has also initiated program plans for each individual fossil energy technology which establishes performance milestones and decision points to judge program progress costs and problems. In addition, specific management plans have been developed for large research, development, and demonstration projects which also establish detailed performance milestones and decision points and defines how the contractor will manage the project.

CONCLUSIONS

DOE has made substantial improvements towards developing the tools needed to properly manage its overall fossil energy research, development, and demonstration program. It has or

is in the process of setting priorities based on the MOPPS study, and developing program and project plans with detailed milestones and decision points by which to judge progress. However, DOE still lacks some of the tools necessary to properly manage its program.

Although the MOPPS study is a step toward establishing program priorities, it does not compare processes using a predetermined set of criteria weighted in accordance with their importance in meeting program goals; nor does it provide the Congress the necessary information to evaluate the adequacy of required funding levels. While several fossil technologies may ultimately be commercialized, all fossil technologies should be thoroughly evaluated and compared to better ensure that those technologies and approaches with the most promise of attaining program goals are commercialized at the earliest feasible time. Thus, the priority-setting process should require such a comparison in the fossil energy research and development planning documents. This evaluation should be supportive of our recommendation in chapter 4 (see p. 35) that DOE evaluate all available fossil energy processes and select the best process for demonstration.

A formal system of priorities would give the Congress a better basis for evaluating the adequacy of required funding levels of the fossil program or for funding alternative approaches. In addition, such a system could place outside organizations--such as other Federal and State agencies and private industry--in a better position to initiate proposals to meet program needs.

DOE has also made significant progress in establishing detailed performance milestones and decision points in its individual program and project plans which are being developed. These plans, however, do not establish cost milestones against which to judge progress in developing fossil technologies into economically competitive fossil energy systems. Such detailed milestones should be developed and included in the individual program and project plans.

In our view, DOE's enhanced oil recovery program plan includes the elements needed for good planning--including a formal system of priorities and cost and performance milestones. In addition, DOE is developing a 5-year program plan for its Underground Coal Gasification Program which, if issued in its current form, will include these necessary elements.

DOE has still not developed specific evaluation criteria for determining when fossil energy technologies or projects have achieved a level of performance to justify advancement to the next phase of development and/or commercialization.

Such criteria should be established to better ensure that the best processes are advanced in a timely manner and to provide the basis for DOE decisions.

Incorporating all of these tools into the planning and management process should put DOE in a better position to ensure that the most promising technology and processes will be developed to the point of eventual commercialization in the form and quantity needed, and at acceptable economic, social, and environmental costs.

RECOMMENDATIONS TO THE SECRETARY, DEPARTMENT OF ENERGY

We recommend that the Secretary, DOE, develop and include as part of the Department's overall and individual program and project plans:

--A system of formal program priorities to be used to allocate limited resources among different fossil energy technologies and among alternative approaches within each technology. This system should be supported by comparative studies, based on a set of predetermined criteria, ranked or weighted according to their importance in meeting program goals.

--Program and project cost objectives for all fossil energy technologies. These objectives should specify target cost limits and dates by which those targets are expected to be met.

--Specific evaluation criteria for determining process advancement.

AGENCY COMMENTS

Responding to this report (see appendix I), DOE agreed with our recommendations and noted that it has efforts underway to improve and enhance its management of individual fossil energy program and project plans. Specifically, DOE said that

--Priorities have been established for the majority of programs and progress is being made on the remaining activities.

--Program plans will include program and project cost objectives.

--Specific evaluation criteria have been established for some projects and efforts are underway for using such criteria for all projects and processes.

We will continue to monitor DOE's progress in improving its program management of fossil energy research and development programs.

CHAPTER 4

WAYS TO IMPROVE THE FOSSIL ENERGY DEMONSTRATION PROGRAM

Some changes should be made in DOE's Fossil Demonstration Plants Program to better achieve early commercialization of fossil energy technologies. These changes relate to the way DOE (1) identifies and selects projects for demonstration, (2) determines the size of the plant required to obtain the necessary information to achieve commercialization, and (3) funds the demonstration projects.

The following sections discuss the objectives of DOE's Fossil Demonstration Plants Program and our proposed changes to that program.

OBJECTIVES OF THE PROGRAM

The successful initiation and completion of the demonstration phase of technology development is vital to the eventual commercialization of any fossil energy technology. DOE has recognized this importance by budgeting about $125 million in fiscal year 1978--or almost 20 percent of the total 1978 fossil energy research and development budget--for demonstrating various processes within six of the seven major fossil energy technologies.

The primary objectives of DOE's Fossil Demonstration Plants Program are to:

--Demonstrate, at near-commercial scale, promising, environmentally acceptable, coal and shale conversion processes which have been developed and evaluated in industry and Government research and development programs.

--Encourage industry participation in the demonstration plants program by providing joint Government/industry funding to minimize industry's risk in accelerating process development.

In meeting these objectives, DOE's general strategy has been to obtain industry participation in a three-phased program for designing, constructing, and operating demonstration plants for the various technologies. Under DOE's program, industry proposes the process and the size and location of the plant, and contributes 50 percent of the costs of constructing and operating the plant. DOE funds all of the design work and the other half of the construction and operating costs.

CHANGES NEEDED IN IDENTIFYING AND SELECTING PROJECTS FOR DEMONSTRATION

In identifying and selecting processes for demonstration, DOE has encouraged industry to submit a number of different processes in responding to a request for proposals and then has selected the best process by evaluating the processes' technical merit, how industry proposes to perform the work; the cost of the process; and the quality of proposed management. The requests for proposals thus allow a great deal of discretion in proposing different processes for demonstration.

The major disadvantage with this approach is that some very deserving, and perhaps better, processes may not be submitted for consideration by industry because of certain requirements in the request for proposals. Such a situation occurred in awarding a contract to Coalcon Company for demonstrating a coal liquefaction process. DOE officials told us that the Department of the Interior's Office of Coal Research expected more processes would be proposed but that industry did not respond as expected due to some of the requirements contained in the request.

In our view, a better approach would be for DOE to establish criteria for evaluating and selecting processes for demonstration (see p. 21 for a discussion of the need for such criteria for the overall research, development, demonstration, and commercialization program), and then evaluate all potential processes against that criteria to select the best processes for demonstration.

The major disadvantage to this preselection process is that competition might be limited or non-existent if one or a few companies held a legal right to the selected process. In our view, however, the advantages to be gained from choosing the best processes (i.e., better chance of successful commercialization) outweigh this disadvantage. In addition, by evaluating all potential processes and developing specific selection criteria, DOE would be in a better position to select an alternative process if the best process is found to be unacceptable due to higher cost.

In establishing its criteria for evaluating and selecting processes, DOE should consider such factors as:

--The contribution that each process can make in meeting the Nation's energy needs within a specified time frame.

--The total time and cost of making the process commercial, including costs of plant construction, of alleviating adverse socioeconomic impacts caused by the

energy development, and costs of providing price supports or further subsidies.

--The incremental cost of producing energy from the process and the means by which that cost would be assimilated by the economy. We have taken the position 1/ that the incremental cost standard, as opposed to "rolled-in" or average pricing, is the only realistic one for making sound economic judgments and treating all emerging energy technologies equally. Incremental cost should be used as a yardstick to judge the various technologies on a priority basis. Separate decisions are made on product pricing considering a number of other social, economic, and institutional factors.

CHANGES NEEDED IN SPECIFYING THE SIZE OF PLANTS REQUIRED

DOE needs to better assure itself that its demonstration plants are of an appropriate size to obtain the necessary information to eventually achieve commercialization by first determining the size of the plant needed to achieve the project's objectives and basing its requests for proposals on that determination. DOE currently allows, within certain general ranges, the potential contractor to determine the size of the plant.

The size of the plants being proposed by industry vary considerably and some, in our view, may not be large enough to obtain the cost and performance data necessary to demonstrate commercial feasibility. For example, DOE has recently awarded contracts to two companies for two high-Btu gasification demonstration plants (see p. 12) and the size of the two proposed projects differ significantly. One plant would be approximately the size of one of the modules of which the future commercial plant would be made up, while the second plant would be only one-fourth to one-fifth the size of a commercial module.

Allowing less than commercial-size modules to be built for a demonstration project creates a two-fold problem:

--Technical scale-up problems are likely to occur when attempts are made to commercialize the process. A number of industry officials told us that even small

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1/"An Evaluation of Proposed Federal Assistance for Financing Commercialization of Emerging Energy Technologies" (EMD-76-10, August 24, 1976).

variances in size can cause technical problems in commercializing the process.

--All of the information necessary to commercialize the technology may not be obtained and further demonstration may be needed. Even if the economic, technical, environmental, and other data can be obtained to industries' satisfaction and extrapolated to commercial operations--which some industry officials do not believe can be done--lending institutions may remain unconvinced. Industry officials told us that financing could be more readily obtained if lending institutions could examine an operating plant using commercial-size equipment.

Conversely, although demonstration plants need to be of a sufficient size to obtain the cost and performance information necessary for demonstrating commercial feasibility, care should be taken to avoid building plants larger than necessary, thereby increasing the amount of financial risk. For example, one potential DOE contractor, with whom DOE is currently negotiating, is proposing to build a full commercial-size, low-Btu gasification plant consisting of three independent modules, when only one module is needed to demonstrate the technology and obtain the needed information.

DOE officials said that a demonstration plant designed for less than three modules would not meet the proposer's objectives and requirements. A smaller plant, it is believed, would incur excessive additional capital costs if and when a decision is made to expand to commercial-size, because duplicate processing units and support facilities would be required if and when the smaller plant were expanded to commercial-size. Therefore, according to DOE, initially building a commercial-size demonstration plant represents the most economical overall approach for the industry participant.

Another important aspect of the design of this commercial-size demonstration plant, according to the industry participant, is to achieve reliability in ensuring uninterrupted gas supply to the industrial users. According to the contractor, a three-unit plant provides flexibility in that gas production could continue, at a reduced output, if an item of equipment in one module were shut down for emergency repairs.

Although we recognize that building commercial-size plants offers a number of benefits for industry, such plants are not needed to meet DOE's demonstration plant objectives and would be built at additional risks and costs to the taxpayers. DOE officials recognize that only a single module is needed to demonstrate the technology and obtain the needed

information, but said that a larger plant is needed to meet the needs of the industry participant and to avoid the additional costs of changing the support and processing units to meet the needs of a commercial plant after the demonstration is completed.

In our view, the size of the demonstration plant should be geared to reaching DOE's objective for obtaining the information necessary to achieve eventual commercialization rather than meeting all of industries' needs. The essential element of DOE's demonstration program is the information to be obtained through the design, construction, and operation of the plants, not the amount of output. Commercialization can be obtained, as DOE has recognized, through the operation of a single modular plant using commercial-size components.

In our view, a better approach would be to base requests for proposals on a determination of the optimum plant size to achieve program or project objectives. This approach could be taken after DOE has completed its evaluation of available processes and has selected the best processes for demonstration.

NEED FOR A MORE FLEXIBLE COST-SHARING POLICY

DOE does not have an industry/Government cost-sharing policy that provides the flexibility needed to achieve timely commercialization of the best emerging coal conversion technologies. As noted previously, DOE allows the proposer to propose the process type, location, and size in exchange for funding half of the demonstration plant construction and operation costs. Design costs are fully funded by DOE.

DOE officials believe the concept of joint DOE/industry participation will accelerate process development, enhance technology transfer, and result in smooth transition to commercial applications thereby aiding in obtaining adequate domestic energy supplies as early as practicable. Cost sharing is viewed as a particularly effective means of implementing the philosophy of joint participation. As stated by a DOE official in a congressional hearing:

> "Cost sharing serves as a pragmatic indication that a project has credibility by the standards of the private sector. Commitment of capital by industry will be followed by subsequent commitment of competent people and management attention to protect that investment * * *"

Although there are advantages and disadvantages of cost sharing to both industry and Government, we agree that the cost-sharing concept is basically a good one. It will, at

least in theory, limit proposals to only credible ones and lower the Government's overall costs.

However, we noted two problem areas stemming from DOE's fixed-cost-sharing policy:

--The cost-sharing percentage needs to be more flexible to recognize both the priority for developing the process as well as the risks involved.

--Cost sharing should take place at the beginning of a project rather than after design work is completed.

The cost-sharing amount

In DOE's cost-sharing policy, industry provides 50 percent of the total cost of constructing and operating the demonstration plant.

The 50 percent cost-sharing amount is imposed on DOE by the Office of Management and Budget, although no directives have ever been issued to that effect. However, in response to questions raised by the Subcommittee on Energy Research, Development, and Demonstration of the House Committee on Science and Technology in hearings, on ERDA's 1977 Fossil Fuels Authorization, ERDA said that this policy is not rigid since, in the proposal evaluation, a cost/price analysis is included to compute the cost of the proposed contract to the Government. This cost is compared to the benefits before awarding the contract. They went on to say that, if a proposal is clearly superior on its technical and economic merit, the cost to the Government becomes a secondary consideration, and the agency could accept a proposed project with more or less than 50 percent cost-sharing amounts. If this were the case, ERDA said that the agency would make it known to the appropriate participants in the budget process, including the Congress.

DOE has never made such an award, however, even though in at least one case it judged one high-Btu gasification process to be technically superior to one of the processes selected for demonstration but was eliminated from competition primarily because the proposer was unwilling to accept the 50-50 cost-sharing requirements.

Furthermore, because the current request for proposals clearly states that DOE is expecting 50 percent of the costs to be borne by the contractor, it is unlikely that a proposer would spend the rather large sums of money to prepare a response which stated otherwise.

Some industry officials we talked to opposed the strict 50 percent cost-sharing policy. They contend that the policy unduly restricts the number of industries which would be able to participate in DOE's program because of the large sums of money needed. They said that the relatively few number of industry responses which DOE has received to its requests for proposals is a good example of this effect.

The conference report on ERDA's 1978 authorization bill also expressed some dissatisfaction with the rigid cost-sharing policy. The conferees said that the rigid policy limits flexibility and provided for a $10 million study to examine the feasibility for a Government-owned, contractor-operated high-Btu gasification facility which would demonstrate and evaluate several second and third generation gasification technologies in a single installation to open up possibilities which are precluded by the present financial arrangements.

There are several alternatives to the strict 50 percent rule, including (1) total Government funding using a Government contractor to operate the plant; (2) a flexible policy in which the proposer would select the cost-sharing amount; and (3) a flexible cost-sharing percentage set by DOE in each request for proposal.

Government-owned contractor-operated demonstration plants would allow total Government control of the project and, according to some industry officials, would speed up the demonstration process because DOE would not have to negotiate or share the decisionmaking process with industry. This approach has one major shortcoming, however--the processes must ultimately be used by industry and a Government-owned contractor-operated plant does not lend itself to widespread industry involvement. In the current cost-sharing arrangement, various companies join together to fund the potential project and these companies take an active role in constructing and operating the project. Hopefully, if the plants are successful, these companies will also take an active interest in commercializing the technology.

Some industry officials argue that the second alternative--allowing the bidders to select the percentage of cost-sharing--would increase the number of responses received by DOE. Under this approach, however, the cost-sharing percentage would become a major factor in determining which proposer to select. It would become very difficult to make a selection if, for example, the best technical proposal had the least advantageous cost-sharing arrangement. There is also a possibility that, once a lower percentage is accepted by DOE, it would be used by proposers of other projects as the new acceptable level

In our view, the third alternative--having a different cost-sharing percentage set forth in each request for proposal --is the best. The predetermined percentage could be based on the degree of risk and priority involved and could be higher or lower than DOE's current 50 percent. By varying the percentage rates on particular projects, DOE would be recognizing the priority and problems of each technology to be demonstrated. Such an approach would require that DOE evaluate each process in detail, as discussed on page 27, to determine the priority of and risks involved in demonstrating each process.

Based on the results of this evaluation, DOE could determine what the cost-sharing arrangement should be. If, for example, DOE determined that a process has a high priority for demonstration but that it is very risky, a lower cost-sharing rate might be requested. Through this approach, DOE would show a sense of urgency in the high priority areas, as well as have a basis for setting the cost-sharing percentage.

We favor the third alternative primarily because it gives DOE control over the cost-sharing amount and has the advantages that cost-sharing offers without the disadvantage of eliminating technically superior processes based on an arbitrarily established cost-sharing amount.

Timing of cost sharing

DOE currently fully funds the design work and cost sharing does not begin until the construction phase begins. DOE justifies this approach on the basis that it wants to make more than one award for designing different processes and, at the completion of that work, select one contractor to proceed to construction, thereby achieving design competition. Since neither contractor is assured that it will be awarded the construction contract, DOE believes neither contractor should be required to share costs prior to construction.

This approach does not take full advantage of the benefits that can be gained from cost sharing--industry participating in the design phase to achieve the best design at the lowest cost.

ERDA's attempt to design and build a coal liquefaction demonstration plant with Coalcon Company is a good example of what could happen when cost sharing is not used in the design phase. In that project, the design phase incurred a substantial cost overrun and a 14-1/2 month schedule slippage. Although the industry contractor was willing to proceed with the design phase when ERDA was funding all of the costs--it

decided that the project required additional research and development work after ERDA attempted to enter the construction phase, where cost sharing was required, and the project was terminated. Although it is difficult to predict whether requiring industry cost sharing from the beginning of this project would have better ensured its success, we believe that it would have made industry more committed to the project's successful completion and could have helped avoid the extensive cost overruns and delays.

Cost sharing should be used from the beginning of the project. In our view, such an approach would help ensure that only the best processes are demonstrated and that the project would be completed in a timely and cost effective manner. It would also give an early indication of industries' willingness to commit funds to the project.

Achieving design competition and, at the same time, encouraging both contractors to share in the design costs when only one will be chosen to build and operate the plant would be impractical. However, implementation of our suggestions for improving DOE's process selection procedures (see p. 27) would better ensure that DOE is issuing requests for proposals for the best processes and would, in our view, eliminate the need for duplicate design efforts. Under this suggested system, the benefits to be derived from duplicate design efforts do not justify the additional costs incurred.

Industry officials told us they did not have any problems with some form of cost sharing from the beginning of the project. They did complain, however, that DOE has the unilateral authority to decide whether the project should go forward to the construction phase--industry has no choice. DOE justifies this approach on the basis that it funds all of the design work. In view of the large sums industry may be investing in these joint projects, DOE should develop a procedure which would allow industry to input into the decisionmaking process when a project is proceeding from one phase to another.

CONCLUSIONS

We have discussed several changes that we believe should be made to the Fossil Demonstration Plants Program to better achieve the program's goals. In short, DOE and its predecessor--ERDA--have been relying too heavily on private industry to specify the process type, size, and location of demonstration plants rather than taking an active lead in evaluating all of the candidate processes within a technology, choosing the best processes, plant sizes, and cost-sharing amounts needed to meet program and project goals, and going forward with requests for proposals based on such an evaluation.

Specifically, DOE and its predecessor--ERDA--have been:

--Issuing broad requests for proposals and relying on industry to choose processes to be considered, rather than establishing selection criteria, evaluating each alternative process in detail against that criteria, and selecting the best ones for demonstration.

--Either issuing contracts for demonstration plants which are not large enough to obtain the needed commercialization data or considering issuing contracts for plants which are larger than necessary to meet project objectives, rather than determining beforehand the size of the plant required to achieve the objectives.

--Requiring a rigid 50-50 cost-sharing policy with industry which, in at least one case, has resulted in a technically superior process being eliminated from consideration, rather than basing the policy on the special circumstances and risks associated with each individual project.

--Fully funding the design phase of project development and cost sharing with industry in the construction and operation of demonstration plants rather than requiring cost sharing from project conception to give industry added incentive to achieve the best design at the lowest cost.

RECOMMENDATIONS

To improve the Fossil Plants Demonstration Program, we recommend that the Secretary, DOE:

--Establish specific criteria for evaluating and selecting processes for demonstration. These criteria should consider the (1) contribution that each process can make in meeting the Nation's energy goals; (2) total cost and timing of commercializing the process; and (3) incremental cost of producing energy from the process and the means by which that cost would be assimilated by the economy.

--Evaluate in detail all potential processes within each fossil energy technology and, based on the selection criteria discussed above, select the best processes for demonstration. The selected processes, and their timetables for development, as well as the criteria used to select them, should be included in DOE's overall research, development, and demonstration program plans as recommended in chapter 3 (see p. 21).

--Change the approach in specifying the size of the demonstration plants needed to obtain the necessary commercialization information by determining beforehand the size of the plant needed to achieve program and/or project objectives and basing its request for proposals on that determination.

--Change the cost-sharing policy to provide for more flexibility in achieving program and/or project goals. This should be done by (1) varying the cost-sharing amount for each process and request for proposals depending on the priority that is assigned to the process and the relative risks involved in constructing and operating a demonstration plant, and (2) requiring cost sharing with industry from the beginning of the project while, at the same time, developing a procedure which would allow industry to input into the decision-making process when a project is proceeding from one phase to another.

AGENCY COMMENTS AND OUR EVALUATION

In its July 6, 1978, comments, DOE said that it concurred with our recommendations about (1) establishing criteria for evaluating and selecting processes for demonstration, (2) evaluating all potential processes within each fossil energy technology as a basis for selecting the best processes for demonstration, and (3) changing the cost-sharing policy. DOE said that it is undertaking action to implement these recommendations.

DOE disagreed, however, with our recommendation about specifying the size of demonstration plants. It said that the Congress has required industry participation in fossil fuel demonstration projects and that DOE requests for proposals were structured to meet these congressional requirements. DOE went on to say that these requests for proposals have resulted in a variety of sized projects which, taken together, provide indepth data from which private industry can commercialize these (and other similar) technologies with private funds. It said that the family of co-offerors for the current demonstration projects represent the broadest range of potential synthetic-fuel commercial entrepreneurs. DOE also emphasized that the decision and selection of size of the demonstration plant is made by DOE, not by industry, and is based on the objective of obtaining adequate technical/economic data to enable commercial scale-up.

We agree that there is a congressional requirement for industry participation in fossil energy demonstration projects.

We do not believe that implementation of our recommendation to determine beforehand the size of the plant needed to achieve program and/or project objectives and basing requests for proposals on that determination would result in any less participation than currently exists. Our concern is that allowing industry to specify the size of the plant through the proposal process and then deciding on the plant to be funded, will result in a plant that could be larger or smaller than is needed to achieve the project's objectives, either too small to be used as a basis for scaling up to a commercial operation or too large and thereby increasing the Government's cost and the amount of financial risk.

We agree that DOE's approach results in a variety of different size demonstration plants. Therein lies our problem. Achieving a variety of different sizes is not necessarily a worthwhile objective. Such an approach may--or may not--result in a project of the optimum size which will obtain the needed data but, in the process, may fund other projects which are either too small or too large. In short, it is a "hit or miss" approach. In our view, a better and more logical approach would be to make a conscious and informed decision on the optimum size required and basing the requests for proposals on that decision.

CHAPTER 5

SCOPE OF REVIEW

We interviewed (1) ERDA and DOE officials responsible for the activities discussed in this report, (2) contractors involved in ERDA research, development, and demonstration programs, (3) Office of Management and Budget officials, (4) representatives of various energy organizations and institutions, and (5) knowledgeable industry officials.

We also reviewed publications relating to the subject matter, and pertinent agency program documents and files.

Department of Energy
Washington, D.C. 20545

July 6, 1978

Mr. Monte Canfield, Jr.
Director, Energy and Minerals
Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Canfield:

We appreciate the opportunity to review and comment on the GAO draft report entitled "Fossil Energy Research, Development, and Demonstration Program: Opportunities for Change." We have reviewed the draft with members of your staff and we understand that some changes and clarifications will be made. Our comments with respect to the recommendations made by GAO to the Department of Energy are discussed below.

GAO Recommendations

The Secretary, DOE, develop and include as part of the Department's overall and/or individual program and project plans:

- A system of formal program priorities to be used to allocate limited resources among different fossil energy technologies and among alternative approaches within each technology. To make visible the bases for establishing priorities, this system should be supported by comparative studies, based on a set of predetermined criteria, ranked or weighted according to their importance in meeting program goals.

- Program and project cost objectives for all fossil energy technologies. These objectives should specify target costs and dates by which those targets are expected to be met.

- Specific evaluation criteria for determining process advancement.

DOE Comments

As indicated in the report, DOE has efforts under way to improve and enhance our overall management of individual fossil energy program and project plans. Specifically, priorities to allocate resources

among different fossil technologies have been established for the majority of programs and projects and progress is being made on the remaining activities, principally through the extensive use of detailed budget backup to our zero-based budget process. It is intended that the bases for establishing priorities will be fully visible and completely supported. Our overall plans will also include program and project cost objectives, including target dates and costs which are expected to be met.

Specific evaluation criteria have been established by fossil energy program offices for some projects and processes in conjunction with two task forces on Technology Transfer and a series of commercialization task forces. Other projects and processes are being examined in the same manner with the objective of setting and using such criteria for all projects and processes.

GAO Recommendation

Establish specific criteria for evaluating and selecting processes for demonstration. This criteria should consider the (1) contribution that each process can make in meeting the Nation's energy goals; (2) total cost and timing of commercializing the process; and (3) incremental cost of producing energy from the process and the means by which that cost would be assimilated by the economy.

DOE Comment

We concur with this recommendation and we are undertaking action to establish specific criteria for evaluating and selecting processes for demonstration. It should be noted, however, that in many instances tests must be run before a determination can be made as to how well the process satisfies, or will satisfy, the criterion.

GAO Recommendation

Evaluate in detail all potential processes within each fossil energy technology and, based on the selection criteria discussed above, select the best processes for demonstration. The selected processes, and their timetables for development, as well as the criteria used to select them, should be included in DOE's overall research, development, and demonstration program plans as recommended in Chapter 3 (see p. 24).

DOE Comment

We concur with this recommendation and, as previously indicated, we are actively working to include timetables for development and selection criteria in our overall fossil energy research, development, and demonstration program.

GAO Recommendation

Change the approach in specifying the size of the demonstration plants needed to obtain the necessary commercialization information by determining beforehand the size of the plant needed to achieve program and/or project objectives and basing its request for proposals on that determination.

DOE Comment

The Congress has required industry participation in fossil fuel demonstration projects to assure that the government program will support the eventual proliferation of the technologies by many private participants and to assure that the products of these technologies can penetrate the market. Thus, DOE requests for proposals were structured to meet these Congressional requirements and have resulted in a variety of sized projects which, taken together, provide in-depth data from which private industry can commercialize these (and other similar) technologies with private funds. It should be noted that the family of co-offerors for our current demonstration projects who will finance half the cost, represent the broadest range of potential synthetic-fuel commercial entrepreneurs. However, the decision and selection of size of the demonstration plant is made by DOE, not by industry, and is based on the DOE objective of obtaining adequate technical/economic data to enable commercial scale-up.

GAO Recommendation

Change the cost-sharing policy to provide for more flexibility in achieving program and/or project goals. This should be done by (1) varying the cost-sharing amount for each process and request for proposals depending on the priority that is assigned to the process and the relative risks involved in constructing and operating a demonstration plant, and (2) requiring cost-sharing with industry from the beginning of the project while, at the same time, developing a procedure which would allow industry to input into the decision-making process when a project is proceeding from one phase to another.

DOE Comment

We agree that a 50% cost-sharing rule can tend to limit flexibility in achieving program and/or project goals and we will, depending upon the particular circumstances and conditions surrounding the proposed arrangement, seek to alter the 50% sharing rule and also consider industry input to the decision-making process as may be appropriate.

Sincerely,

Fred L. Hiser, Director
Division of GAO Liaison

PRINCIPAL OFFICIALS RESPONSIBLE FOR ADMINISTERING ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office From	To
DEPARTMENT OF ENERGY		
Secretary of Energy:		
James R. Schlesinger	Oct. 1977	Present
Deputy Secretary of Energy:		
John F. O'Leary	Oct. 1977	Present
Assistant Secretary for Energy Technology:		
Robert D. Thorne	Oct. 1977	Present
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION		
Administrator:		
Robert W. Fri (Acting)	Jan. 1977	Oct. 1977
Robert C. Seaman	Jan. 1975	Jan. 1977
Assistant Administrator for Fossil Energy:		
S. William Gore, Jr. (acting)	Jan. 1975	June 1975
Philip C. White	June 1974	Oct. 1977

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