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REPORT TO THE CONGRESS

Federal Coal Research --
Status And Problems
To Be Resolved

Multiagency

**BY THE COMPTROLLER GENERAL
OF THE UNITED STATES**

RED-75-322

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ABBREVIATIONS

AEC	Atomic Energy Commission
AGA	American Gas Association
BOM	Bureau of Mines
Btu	British thermal unit
COG	coal-oil-gas
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
FEA	Federal Energy Administration
GAO	General Accounting Office
MHD	magnetohydrodynamics
NSF	National Science Foundation
OCR	Office of Coal Research
OMB	Office of Management and Budget
ORD	Office of Research and Development
TVA	Tennessee Valley Authority

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

FEDERAL COAL RESEARCH--STATUS
AND PROBLEMS TO BE RESOLVED
Multiagency

D I G E S T

WHY THE REVIEW WAS MADE

GAO made this review to determine the status of the Federal Government's coal research programs and the problems which need to be resolved so that these programs may contribute to reducing the Nation's energy problems.

FINDINGS AND CONCLUSIONS

The potential for increased development and use of U.S. coal resources in meeting increased energy demands is great.

However, for coal to play an important role, three developments are essential.

- Research must demonstrate the commercial feasibility of converting coal to other sources of energy.
- The coal industry must be willing to finance and be capable of supplying increasing quantities of coal.
- Environmental problems associated with coal supply and use must be resolved rationally.

Coal research activities

The Energy Reorganization Act of 1974 authorized the establishment of an Energy Research

and Development Administration to bring together and direct Federal activities relating to research and development in the various energy sources.

It established also an Energy Resources Council to coordinate energy policy and management matters and to advise the President and the Congress on future reorganizations of energy and related functions in the Federal Government.

Before the authorization of the Energy Research and Development Administration, there was no focal point for Federal coal research program efforts. Coal research had evolved over a period of years in response to the specific missions of the Federal agencies, with each agency pursuing its own objectives, priorities, and goals. (See p. 9.)

Although actions had been taken previously which strengthened the direction of the Federal coal research program, the establishment of the new agency was a major step in the direction of developing a unified, coordinated Federal coal research program.

The Federal Government's coal research activities were principally funded through two agencies of the Department of the Interior--the Office of Coal Research and the Bureau of Mines. (See p. 13.)

The Environmental Protection Agency (see p. 16), the Tennessee Valley Authority (see p. 17), and the National Science Foundation (see p. 18) also funded coal research activities, but to a lesser extent than the Department of the Interior. In addition, the Federal Energy Administration had taken actions which impacted on coal research activities as part of its overall role for improved management and coordination of Federal energy resources activities (see p. 20).

Funding for coal research projects by the Federal agencies increased from about \$48 million in fiscal year 1970 to about \$167 million in fiscal year 1974 and totaled about \$463 million during that period. Coal research funding for fiscal year 1975 is estimated at about \$566 million. (See p. 21.)

Funding of over \$2 billion for increased coal research activities during the fiscal years 1975 through 1979 has been proposed by the Chairman of the Atomic Energy Commission as a result of a study ordered by the President on an integrated national energy research and development program. (See p. 27.)

From fiscal year 1970 through fiscal year 1974, most of the Federal coal research funds were expended on use research--about \$342 million, or 74 percent, compared with about \$121 million, or 26 percent, for supply research.

Coal use research activities

have been primarily directed to the conversion of coal to synthetic gas or oil, the direct use of coal in electric power generation, and the abatement of pollutants resulting from the burning of coal.

Coal supply research activities have been primarily directed to mining health and safety, in response to mine safety legislation. (See p. 9.)

Coal research activities also are being carried out by other than Federal agencies and organizations and by foreign countries, but the extent of such activities is difficult to determine because:

--No formal means exist for obtaining and disseminating such information from the various sources.

--Non-Federal sources are reluctant to disclose research information which they consider to be of a proprietary nature. (See p. 24.)

Coal use research

During fiscal year 1974, 21 advanced coal use research projects were in various stages of development and about \$176 million in Federal and non-Federal funds had been expended through June 30, 1974.

Ten were gas conversion projects, five were liquid conversion projects, and six were electricity conversion projects.

Of the 21 projects, 17 were funded by the Office of Coal Research, 3 by the Bureau of Mines, and 1 by the Environmental

Protection Agency. In addition, EPA was funding six projects to remove pollutants resulting from the direct combustion of coal and through June 30, 1974, had spent about \$44 million. (See pp. 33, 56.)

Most of the advanced coal conversion projects were in the pilot plant or laboratory stage in fiscal year 1974. Estimated costs for commercial plants for the processes range from \$100 million to \$785 million a plant, depending on numerous variables including the types of processes included. (See p. 33.)

Federal research officials do not expect the Federal research efforts in the conversion of coal to synthetic gas and oil and the direct use of coal in electrical power generation to produce commercially acceptable processes until the late 1970s or mid-1980s. (See p. 33.)

Although Federal research efforts have produced six advanced processes to remove pollutants resulting from the direct combustion of coal and some of these processes are commercially available, they are not as efficient or as economical as desired. Estimated costs to install these processes in electrical generation plants range from \$35 to \$43 million for a new 1,000 megawatt plant to \$52 to \$68 million for an existing 200 megawatt plant. (See p. 33.)

Potential problems which may delay commercializing various coal conversion processes include:

--Possible lack of specialized equipment--Private industry may not have the capability or plant capacity to fabricate and erect equipment needed for conversion plants. (See p. 58.)

--Need for early plantsite location--The potential sites having adequate coal and water supplies must be identified, contracts negotiated, use permits obtained, and environmental impact studies conducted, and these activities take time. (See p. 59.)

--Substantial capital requirements--If current coal conversion research is successful, financial incentives or other Federal assistance may be required to induce private industry to finance such ventures. (See p. 61.)

Coal supply research

This research--land reclamation, coal extraction, and mining health and safety--has been funded almost entirely by the Bureau of Mines, and only \$1.5 million, or 1 percent, has been spent for coal extraction technologies. (See p. 65.)

Coal industry experts and other energy authorities have questioned the ability of the coal industry, as presently constituted, to meet the projected increased demand for coal because of potential problems in

--mining technology (see p. 68),

--manpower (see p. 69),

--transportation (see p. 71),

--environmental considerations
(see p. 74), and

--capital investment (see p.
73).

The Chairman of the Atomic Energy Commission recognized the need for additional research in coal supply during her review of Federal energy research and development which was made at the direction of the President. She recommended that an additional \$325 million be provided for this research for the 5-year period beginning with fiscal year 1975, most of which would be for coal. (See p. 65.)

RECOMMENDATIONS OR SUGGESTIONS

Federal coal research agencies rely on a voluntary release of information on the coal research efforts of industry and foreign countries, but there is some reluctance to provide such information.

Because a free and full exchange of such information--under proper safeguards to avoid public disclosure of proprietary information--should be of mutual benefit, GAO recommends that the Administrator of the Energy Research and Development Administration in cooperation with the Department of the Interior, the Federal Energy Administration, and other Federal agencies involved in coal research determine whether formal procedures for exchanging research and development information can be developed. (See p. 32.)

Because of the importance of

(1) potential problem areas which could inhibit the transition from the research phase to the commercial production phase for various coal conversion processes and (2) problems presently inhibiting the increase in our Nation's coal supply, particularly the need for improved mining technology, GAO recommends that the Administrator of the Energy Research and Development Administration give these problems early consideration in the planning for future coal research and development efforts.

AGENCY ACTIONS AND UNRESOLVED ISSUES

The Federal agencies involved in coal research or related matters agreed with GAO's facts and recommendations. The Department of the Interior and the Federal Energy Administration both agreed that the Energy Research and Development Administration should determine whether formal procedures for exchanging research and development information can be developed. (See p. 78.)

MATTERS FOR CONSIDERATION BY THE CONGRESS

The Congress should consider:

--The Federal incentives that may be needed to overcome the many problems which may delay the transition from the research phase to the commercial production phase for various coal conversion processes. Incentives may be needed in the areas of (1) development of costly specialized equipment, (2) obtaining plantsite

locations, and (3) capitalization of new conversion industries. (See p. 63.)

--The Federal action and funding needed to overcome the present problems delaying the increase in the Nation's coal supply. Action and funding may be needed for (1) improving mine technology, (2) increasing manpower, (3) new transportation systems, (4) resolving environmental considerations, and (5) incentives to attract private investment. (See p. 77.)

--The need for providing as-

surance to the coal industry that technological breakthroughs in other potential energy-producing sources would not result in a drastic diminution of the role of coal in energy production, as had occurred after 1947 when oil and natural gas became highly competitive. Such assurance would seem to be needed to encourage investment in coal conversion plants, coal mining equipment, and coal transportation facilities as well as to interest sufficient personnel in acquiring the training and skills needed by an expanding coal industry. (See p. 77.)

CHAPTER 1

INTRODUCTION

"Energy," defined as the capability to do work, is essential to the Nation's social, economic, and industrial welfare. The rapid economic and industrial growth of the United States in the past was partially stimulated by abundant supplies of low-cost energy. The United States is consuming vast amounts of energy from five primary energy sources: oil, natural gas, and coal (fossil fuels); nuclear-fueled powerplants; and hydroelectric powerplants.

The U.S. fossil fuel resources are vast, but the greatly expanded use of oil and natural gas--the more easily used, economical, and environmentally acceptable fossil fuels--has created an imbalance in the use of these resources. The demand for oil and gas now exceeds the amount available from domestic sources, and consequently this gap is being filled by foreign supplies. In contrast, however, the United States has abundant domestic reserves of coal available for development.

We made a review to determine the status of the Federal Government's coal research programs and the problems which need to be resolved, so that these programs may contribute to the solution of the Nation's energy problems. The scope of our review is in chapter 6.

ENERGY DEMAND AND SUPPLY

From 1947 to 1970, the U.S. annual energy consumption increased from about 33 quadrillion to 67 quadrillion Btu's.¹ Projections of future energy requirements vary widely, primarily due to the different assumptions made affecting both the supply and demand for energy. A 1972 Department of the Interior forecast of energy consumption through the year 2000 indicates an average annual growth rate of 3.6 percent, which represents about a threefold increase from 1970 to 2000.

¹British thermal unit. It takes 1 Btu to raise the temperature of 1 pound of water 1°F.

According to a Department report, domestic energy supply has not kept pace with energy consumption. As shown on the following page, in 1970 the deficit in domestic energy supply was about 5 quadrillion Btu's and by 1985 the deficit is projected at about 36 quadrillion Btu's.

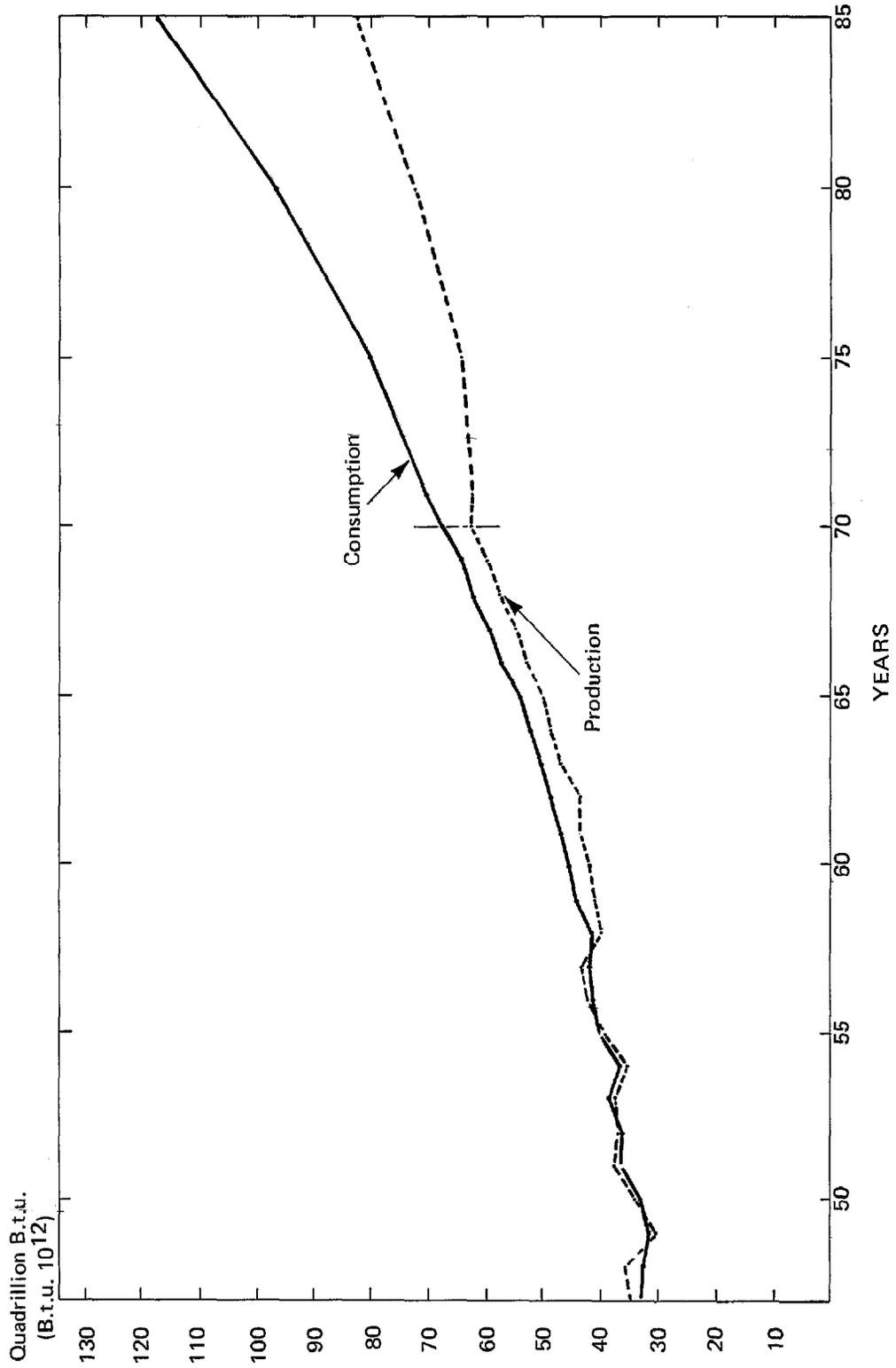
The following data the Department developed shows the percentage of the Nation's total energy needs provided by various sources for 1972.

<u>Source</u>	<u>Percent</u>
Oil	45.6
Natural gas	32.3
Coal	17.2
Water	4.1
Nuclear	<u>.8</u>
	<u>100.0</u>

The Secretary of the Interior's 1973 Report on Mining and Minerals Resource Policy showed that oil and natural gas provided about 78 percent of the Nation's needs. However, foreign sources provided about 29 percent of the oil and 5 percent of the natural gas consumed. Energy consumption forecasts, made before the Arab-bloc countries' decision to stop exporting oil to the United States, indicate an increasing reliance on foreign energy sources as the Nation's energy demands continue to grow. For example, a 1972 Department projection showed that by the year 2000 foreign sources may be expected to supply 70 percent of the Nation's oil needs and 28 percent of the Nation's natural gas needs.

The implications of dependence on foreign energy sources are very broad and suggest a need for more dependence on domestic energy sources. In November 1973 the President announced the beginning of Project Independence, a major project to achieve the capability of energy self-sufficiency by 1985. Its goal was to evaluate the Nation's energy problems and provide a framework for developing a national energy policy.

DOMESTIC ENERGY CONSUMPTION AND PRODUCTION 1947 - 1985



Note 1 Actual amounts for 1947 to 1970 and estimated amounts for 1971 to 1985.

The President subsequently assigned the Federal Energy Office, now the Federal Energy Administration (FEA), the lead role in preparing a comprehensive plan for Project Independence. This plan, which was submitted to the President in November 1974, is an evaluation of the Nation's energy problems and discusses the impacts and implications of a wide range of energy policy alternatives.

The report on Project Independence was developed by interagency work groups and task forces. Among the many task forces were a coal task force and a synthetic fuel task force. These task forces, along with other task forces for other domestic energy sources, were directed to (1) develop supply and demand curves for each energy fuel, (2) determine resources needed to meet various production levels, and (3) identify the constraints on increased production, such as equipment availability, manpower, transportation, financing, and environmental problems. The findings of Project Independence are discussed in chapters 3 and 4 of this report.

There are many ways to reduce the Nation's dependence on foreign energy supplies. Increased development of known domestic coal, oil, and natural gas resources; increased exploration for new domestic oil and natural gas resources, particularly on the Outer Continental Shelf; and increased use of nuclear power offer potential solutions to the Nation's energy problem. These potential solutions have received increased emphasis. The development of new energy sources--such as solar power, oil shale, geothermal power, the harnessing of tides and the extraction of hydrogen fuel from water--also hold promise.

Coal, the Nation's most abundant domestic energy resource, has remained virtually under exploited primarily because of its past inability to compete with the more easily used and economical fuel sources--oil and natural gas--and because of environmental constraints.

DOMESTIC COAL RESOURCES

A U.S. Geological Survey report states that domestic coal resources are far greater than the combined domestic

resources of oil, natural gas, and oil shale. According to a coal industry report, recoverable coal reserves constitute about 88 percent of the Nation's proven reserves of all fuels.

The Department estimates total domestic coal resources at about 3.2 trillion tons, of which about 50 percent has been identified as proven resources by mapping and exploration. The remaining 1.6 trillion tons of coal, classified as probable resources, are within known coalfields which have not been mapped or explored.

Recoverable coal reserves are much smaller than estimated resources because only a fraction of the total resources are considered minable with present technology and under present economic conditions. The Department estimates recoverable coal reserves at about 193 billion tons, which at the present rate of consumption would last about 320 years.

The United States has four types of coal--lignite, subbituminous, bituminous, and anthracite. Each type has a different heat content per pound--lignite, 6,000 to 7,500 Btu's; subbituminous, 8,500 to 11,500 Btu's; bituminous, 11,000 to 15,000 Btu's; and anthracite, 13,500 to 14,500 Btu's.

Of total domestic coal resources, about 43 percent is bituminous, about 55 percent is subbituminous and lignite, and slightly less than 1 percent is anthracite. Practically all lignite and subbituminous coal is found in Alaska and States west of the Mississippi River. Most bituminous coal is found in 10 States principally east of the Mississippi River. Anthracite coal is found primarily in Pennsylvania.

DOMESTIC COAL SUPPLY AND DEMAND

Although coal resources are greater than all the remaining primary domestic fuel resources, coal's contribution to the national energy supply has steadily declined since 1947.

The chart on the following page developed from Department and National Coal Association data shows domestic coal production and coal's contribution to total energy consumption from 1932 to 1972.

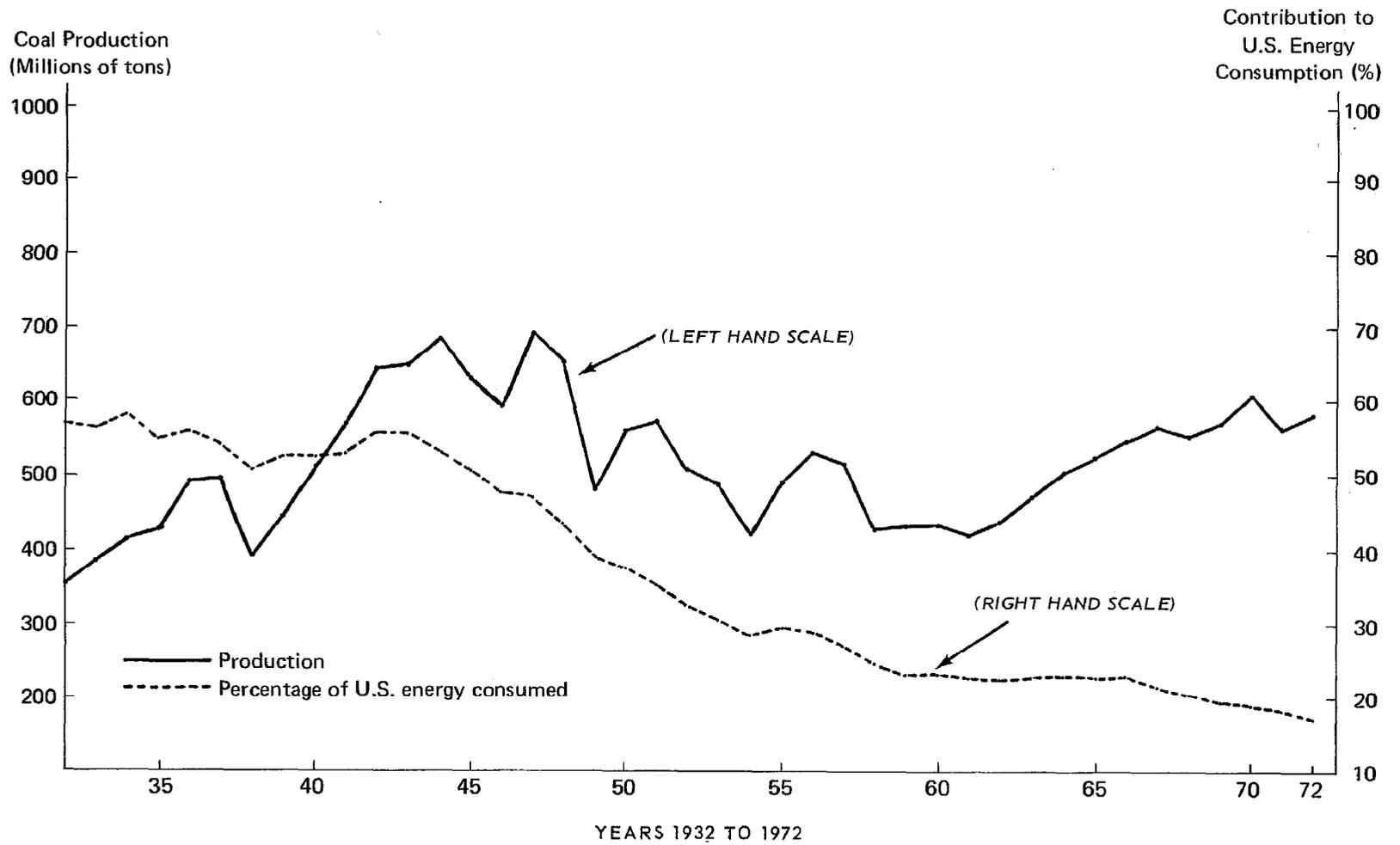
The chart also shows that coal production increased irregularly to an alltime peak of 688 million tons in 1947, when it provided about 51 percent of the Nation's energy needs. After 1947, coal production declined, and in 1961 only 420 million tons were mined. Coal's contribution to the Nation's energy supply also declined to about 26 percent in 1961. The Department attributed the decline in the use of coal from 1947 to 1961 to, among other things, the increased use of natural gas and oil for home heating and to the use of diesel-powered railroad locomotives, rather than coal-burning locomotives.

After 1961 coal production increased, and in 1971 about 600 million tons were mined. However, the percentage of coal's contribution to the Nation's energy supply during this period continued to decrease, and in 1972 coal supplied only about 17 percent of the energy consumed. The Department attributed the increase in coal production after 1961 to increased demand by the electrical utility industry and to the availability of lower cost coal from improved strip-mining operations.

The number of underground coal mines in the United States and the underground coal production have decreased. According to the Department, the number of underground bituminous coal mines, including lignite mines, decreased from 2,939 in 1970 to 2,268 in 1971 and production decreased from about 339 million tons to about 276 million tons. The Department attributed a portion of this decrease in the number of underground mines and underground production to increased cost of operating under the strict safety provisions of the Federal Coal Mine Health and Safety Act of 1969.

In contrast, the number of strip mines and the amount of production from strip mines increased. In 1960, 1,530 strip mines produced about 30 percent of the bituminous coal, whereas in 1972, 2,309 strip mines produced about

U.S. COAL PRODUCTION AND RELATIONSHIP TO ENERGY CONSUMED 1932 - 1972



7

47 percent. Coal industry officials believe that the trend to strip mining must continue because strip mining results in a higher coal recovery rate and is usually more economical.

Demand for coal is expected to triple by 1985, primarily because of the increasing demand by the electric utility industry and the projected demand by the synthetic gas and liquids industry. The Department estimates that by 1985 the demand for coal may increase to about 2 billion tons annually.

The potential for increased development and use of the Nation's coal resources is great. However, for coal to play an important role in meeting the increasing energy demands, research must demonstrate the commercial feasibility of converting coal to other forms of energy; the coal industry must be capable of supplying increasing quantities of coal; and environmental problems associated with coal supply and use must be resolved.

CHAPTER 2

COAL RESEARCH ACTIVITIES

Until October 1974 when the Energy Research and Development Administration (ERDA) was authorized by the Energy Reorganization Act of 1974 (42 U.S.C. 5801), there was no focal point for Federal coal research program efforts. Coal research had evolved over a period of years in response to the specific missions of the Department of the Interior and three other Federal agencies, with each agency pursuing its own objectives, priorities, and goals. Although actions had previously been taken to strengthen the Federal coal research efforts--(1) the establishment in May 1973 of the Office of Research and Development within the Department of the Interior to direct the Department's energy research activities and to coordinate these activities with other agencies and (2) the designation of the Department, by the Office of Management and Budget (OMB), as the lead agency for the development of a Government-wide coal research and development plan--establishing ERDA was a major step in the direction of developing a unified, coordinated Federal coal research program.

Federal coal research activities cover two broad areas --the utilization of coal and the supply of coal. Coal use research includes converting coal to synthetic gas or oil, the direct use of coal in electrical power generation, and pollution abatement. Research in coal supply deals primarily with coal extraction, mining health and safety, land reclamation, and environmental technology.

Funding for coal research projects by the Federal agencies increased from about \$48 million in fiscal year 1970 to about \$167 million in fiscal year 1974 and totaled about \$462 million during that period. Coal research funding for fiscal year 1975 is estimated at about \$566 million. In addition, funding of over \$2 billion for increased coal research activities during the fiscal years 1975 through 1979 has been proposed by the Chairman of the Atomic Energy Commission (AEC), as a result of a study ordered by the President on an integrated national energy research and development program.

Private industry, State governments, academic institutions, and foreign countries also conduct coal research activities. Definitive information on the coal research activities of these entities is not readily available, however, primarily because of the proprietary nature of the information. A free and full disclosure of such information--under proper safeguards to avoid public disclosure of proprietary information--should be of mutual interest and benefit to all parties conducting coal research activities. We believe that the Administrator of ERDA, in cooperation with the Department of the Interior, FEA, and other Federal agencies involved in coal research activities, should explore whether procedures for exchanging such information can be developed.

FEDERAL RESEARCH ACTIVITIES

The Energy Reorganization Act of 1974 impacts considerably on Federal energy research and development matters. The responsibility for planning and managing Federal energy research and development programs is to be consolidated in the ERDA, and the Energy Resources Council was established to coordinate energy policy and management matters and to advise the President and the Congress on future reorganizations of energy and related functions in the Federal Government.

Prior to the enactment of the Energy Reorganization Act, coal research activities were carried out by the Department of the Interior; the Environmental Protection Agency (EPA); the Tennessee Valley Authority (TVA); and the National Science Foundation (NSF). In addition, FEA carried out activities which impact on coal research matters.

The activities of these various Federal agencies and their impact on coal research matters are discussed below.

ERDA

ERDA was authorized to bring together and direct Federal activities relating to research and development on the various sources of energy, to increase the efficiency and reliability in the use of energy, and to carry out the

performance of other functions previously administered by other Federal agencies. Among other things, ERDA responsibilities include:

- Exercising central responsibility for policy planning, coordination, support, and management of research and development programs respecting all energy sources.
- Encouraging and conducting research and development, including demonstration of commercial feasibility and practical applications of the extraction, conversion, storage, transmission, and utilization phases related to the development and use of energy from fossil, nuclear, solar, geothermal, and other energy sources.
- Developing, collecting, distributing, and making available for distribution scientific and technical information concerning the manufacture or development of energy and its efficient extraction, conversion, transmission, and utilization.
- Encouraging and conducting research and development in energy conservation.
- Encouraging and participating in international cooperation in energy and related environmental research and development.
- Helping to insure an adequate supply of manpower for the accomplishment of energy research and development programs.
- Encouraging and conducting research and development in clean and renewable energy sources.

To carry out the purposes of the Energy Reorganization Act, the following functions were transferred to ERDA from other Government agencies.

- All AEC functions, except the licensing and regulatory functions which were transferred to an independent nuclear regulatory commission.

- Department of the Interior functions related to (1) the Office of Coal Research (OCR), (2) fossil fuel energy research and development programs and related activities conducted by the Bureau of Mines and its energy centers and plants, and (3) underground electric power transmission research.
- NSF functions related to solar heating and cooling development and geothermal power development.
- EPA functions related to research, development, and demonstration of alternative automotive power systems.

The provisions of the Energy Reorganization Act were to take effect 120 days after its enactment or on such earlier date as the President may prescribe and publish in the Federal Register. By Executive Order 11834 dated January 15, 1975, ERDA was formally activated January 19, 1975.

Energy Resources Council

The Energy Reorganization Act of 1974 authorized the establishment of the Energy Resources Council to (1) insure communication and coordination among the various Federal agencies involved in energy policy matters or the management of energy resources, (2) make recommendations to the President and to the Congress to improve the implementation of energy policies and the management of energy resources, and (3) advise the President in the preparation of additional recommendations for organization of energy and related functions in the Federal Government, including the advisability of the establishment of a department of energy and natural resources and an energy policy council, and the consolidation of regulatory functions concerning energy.

The Energy Resources Council was formally activated on October 11, 1974, by Executive Order 11814. The Council consists of the Secretary of the Interior, who is its chairman; the Secretaries of State, the Treasury, Defense, Commerce, and Transportation; the Attorney General; the Assistant to the President for Economic Affairs; the Chairman of

AEC; the Director of OMB; the Chairman of the Council of Economic Advisers; the Administrator of FEA; the Administrator of ERDA; the Administrator of EPA; the Chairman of the Council on Environmental Quality; the Director of NSF; the Administrator of General Services; the Director of the Office of Consumer Affairs; the Executive Director of the Domestic Council; and such other members as the President may designate. Authority for the Council will terminate upon the establishment of a permanent department responsible for energy and natural resource matters or on October 10, 1976, whichever occurs first.

Department of the Interior

The Department's coal research activities have been carried out by the Bureau of Mines (BOM) and OCR. BOM and OCR activities were coordinated and directed by the Office of Research and Development.

BOM

BOM, established in 1910, was responsible for stimulating mineral and fuel supply in a manner acceptable to the public interest. In coal research, BOM's objective was to conduct such research as necessary to insure an adequate, dependable, and timely supply of coal at the lowest possible costs to the consumer and the economy, without objectionable occupational work costs in terms of mine health and safety and without objectionable environmental and social costs.

BOM's research covered a wide range of activities from extracting coal through the use of coal as an energy source. As early as 1918, BOM conducted tests of the conversion of coal to synthetic oil. BOM's research efforts shifted over the years, depending on the interest and emphasis placed on the various energy fuels. Since enactment of the Federal Coal Mine Health and Safety Act of 1969 (30 U.S.C. 801 et seq.), BOM's major research efforts were directed to coal mine health and safety. In recent years, however, research in the conversion of coal to synthetic gas and oil received increased emphasis.

BOM's research activities were carried out primarily through six energy, eight metallurgy, and four mining

research laboratories and field offices. Research projects were proposed by BOM research supervisors and were subjected to a series of reviews by laboratory, field office, and headquarters officials before approval. Ongoing research projects were reviewed periodically by the laboratory or field office and BOM headquarters officials. In recent years, however, BOM placed increased emphasis on contracting with non-Federal organizations to carry out coal research projects.

The research functions of BOM with respect to the conversion of coal to synthetic gas and oil will be transferred to ERDA. BOM's research functions with respect to coal extraction, land reclamation, and mine health and safety will remain in the Department of the Interior.

OCR

OCR was established in 1961 to develop technology for new and more efficient methods of mining, preparing, and utilizing coal to insure abundant supplies of clean energy. The specific objectives of OCR's research program are to provide technology for converting coal into clean energy forms, to develop more efficient ways of producing electrical power from coal, and to reduce the United States dependence on foreign oil and gas imports.

Since its establishment, OCR's research efforts have been directed primarily toward converting coal to more environmentally acceptable energy forms, particularly converting coal to synthetic gas. In recent years, research directed toward converting coal to synthetic oil and electricity received increased emphasis.

All OCR research activities were carried out through contracts with private industry, other Government agencies, and academic institutions. Research activities in converting coal to synthetic gas were cosponsored and jointly funded with private industry. OCR anticipated similar cooperation with private industry in future years in carrying out research activities in converting coal to oil and electricity.

Proposals received from prospective contractors formed the basic framework from which OCR developed its coal research program. Recently, however, OCR began to change its method of operation from responses to unsolicited proposals to requests to prospective contractors for proposals which met the need for additional research in areas of planned technological development. Contractor proposals were reviewed by OCR's evaluation staff, by technical evaluators under contract with OCR, and by BOM prior to approval to ascertain their technical and economic feasibility and to eliminate possible duplication with other projects. Ongoing projects were periodically monitored by OCR, as well as by special engineering and evaluation firms under contract with OCR.

All OCR functions will be transferred to ERDA.

Office of Research and Development

The Office of Research and Development (ORD) was established in May 1973 by the Secretary of the Interior to strengthen the Department's capabilities for overseeing and coordinating a broader range of energy research and development activities. ORD's objectives were to guide the various research programs in the energy and mineral areas; setting priorities; formulating budgets; evaluating progress and results; and, in general, insuring that research and development efforts are oriented to the objectives set forth by the Secretary. ORD had the added objective of cooperating with other organizations in the Department and agencies of the Federal Government to insure the effective use of existing information and coordination of ongoing programs involving interagency participation, to avoid both research and development gaps and duplication of effort.

ORD's Director said that in the past both BOM and OCR had conducted similar research programs, although there had been no technical overlap in the research projects. He stated that, in order to strengthen the Department's overall coal research program, ORD had established a unified coal research program within the Department which provided clearer lines of research responsibilities between BOM and OCR. The Director explained that the goal of the unified coal research program was to (1) concentrate all coal

utilization research projects which had reached the advanced, large scale, pilot plant or demonstration plant stage and indirect support research for such projects within OCR and (2) concentrate all basic coal utilization research laboratory scale development and mining technology research within BOM. OCR would not undertake new research activities in coal mining. Such activities would be concentrated in BOM.

The Director further stated that ORD had implemented the unified coal research program through the use of three major task forces in coal conversion, coal mining, and advanced power systems.¹ Each task force was composed of representatives of agencies within the Department of the Interior and was responsible for the technical review, budget planning, and assignment of proposed research projects within its area of responsibility. The technical merits and budget planning for each proposed coal research project were required to be reviewed by the task forces, and the approved projects were assigned to either BOM or OCR within the framework discussed above.

EPA

Since its establishment in 1970, EPA has carried out coal-related research activities to prevent and control air and water pollution. EPA had conducted coal related research to develop improved low-cost techniques to (1) remove air pollutants prior to and after the combustion of coal, (2) improve the efficiency of fuel combustion, (3) dispose of the undesirable products of coal combustion, and (4) produce synthetic or new fuels which result in decreased air pollution. EPA had also conducted research on the control of pollution resulting from mining activities through its water pollution control research program. These activities, which relate primarily to the control of acid drainage from inactive mines, were discussed in our report to the Congress entitled "Research and Demonstration Programs to Achieve Water Quality Goals: What the Federal Government Needs to Do" (B-166506, Jan. 16, 1974), and they are not discussed in this report.

¹Systems which increase the efficiency of conventional power generating systems.

The major thrust of EPA's research efforts have been in the removal of pollutants after coal combustion by means of stack gas cleanup.

EPA's research activities are carried out through (1) contracts with private industry and other Government agencies, primarily BOM and TVA, (2) grants to academic institutions, and (3) its own laboratory. All research proposals are required to be evaluated by the EPA research laboratory in accordance with established research objectives and priorities. Ongoing projects under contract or grant are required to be evaluated by the EPA research laboratory either at planned milestones or at least once a year, whereas in-house efforts are scheduled for evaluation once a month.

EPA's coal research functions will not be transferred to ERDA. EPA said that the transfer of such functions was not included in the Energy Reorganization Act because EPA's coal related research and development programs relate primarily to its regulatory functions and to transfer the programs to ERDA might severely restrict its statutory mandates related to the control of pollution from coal.

TVA

TVA, a corporation owned by the Federal Government, was established in 1933 to develop and conserve the resources of the Tennessee Valley. The objective of TVA's coal research activities is to develop methods of generating electricity in an environmentally satisfactory manner.

Until about 1970, TVA's coal research activities were directed primarily to removing sulfur dioxide from coal combustion emissions. Recently, research activities have been directed toward sulfur dioxide and nitrogen oxide removal and the conversion of coal to synthetic gas for use in electric power generation. TVA officials said that these research activities would in all probability continue to receive emphasis in the future.

Research activities are managed by TVA's Power Research Staff and carried out by in-house staff, through agreements with other Government agencies, through contracts with

private industry, and through academic institutions. A substantial portion of TVA's in-house efforts consists of contract research for EPA. In-house research activities are conducted at TVA powerplants and various laboratories.

Research proposals are generated by the TVA Power Research Staff, other Federal agencies, and private industry. Proposals costing \$100,000 or more, or involving contractual payments of \$25,000 or more, or which involve novel or significant program or policy considerations must be reviewed by the General Manager. He submits to the Board of Directors for its approval projects which cost \$200,000 or more or which involve significant policy considerations. Lesser projects are approved by the Manager of Power, on the recommendation of the Power Research Staff.

Approved projects are evaluated on a continuing basis by the Power Research Staff, and progress reports are provided to TVA's Board of Directors for further evaluation. Monthly progress reports and final project reports are provided to those other Federal agencies which funded the research. For research funded solely by TVA, the Director of the Power Research Staff determines the distribution of final project reports. Generally, such reports are also distributed to other Federal agencies and members of the Electric Power Research Institute, an association representing public and private utilities.

The Energy Reorganization Act did not transfer any of TVA's coal research functions to ERDA, and a TVA official said that ERDA's establishment would have no direct impact on TVA's research activities. He did state, however, that, because some of TVA's coal research projects had been funded by Federal agencies which would be transferred to ERDA, there could be some indirect impact on the funding for these projects.

NSF

NSF was established in 1950 to sponsor basic research and education in the sciences. In 1968 NSF's authority was extended to include support of applied research. According to an NSF official, NSF was not directly involved

in coal research activities prior to fiscal year 1972. Currently, however, NSF is sponsoring coal-related research to develop the knowledge base for new or improved technology which can be transferred to and carried out by other Federal agencies or industry involved in coal research at a more advanced stage. NSF officials said that future coal research would continue in this same general area.

All NSF-sponsored research is conducted by academic institutions and private industry through research grants or contracts. Project proposals are received from academic institutions, private industry, and Government agencies and complete with non-coal-related research proposals for funding. Research proposals relating to coal are forwarded for comment to knowledgeable NSF scientists and officials, other Federal agencies involved in coal research, and to knowledgeable experts in the academic and private scientific community, such as the Electric Power Research Institute. NSF officials told us that, if, in this review process, the proposal is not favorably commented upon or the reviewers do not encourage the approval of the proposal, the project will generally not be approved. Ultimate approval of the project, however, rests with NSF.

Once a project is approved, it is monitored by the designated NSF program manager with the assistance of an advisory committee made up of professionals who are experts in the project field. The advisory committee meets periodically with the scientist conducting the research to evaluate progress and management of the project, the results achieved, and methods needed to resolve any problems.

At the completion of a project, the results are published and circulated to OCR, BOM, AEC, and other Federal agencies interested in or involved in the research area as well as the Electric Power Research Institute and private industry. Final reports are also filed with the National Technical Information Service, Department of Commerce, which is a clearinghouse for the collection and dissemination of scientific, technical, and engineering information from both Government and non-Government sources.

NSF's coal research functions were not transferred to ERDA by the Energy Reorganization Act. An NSF official told

us that, although these functions were not transferred, the establishment of ERDA could effect NSF's coal research activities. He said however, that, until ERDA was formally established and became operational, it was not clear what effect ERDA would have on these activities.

FEA

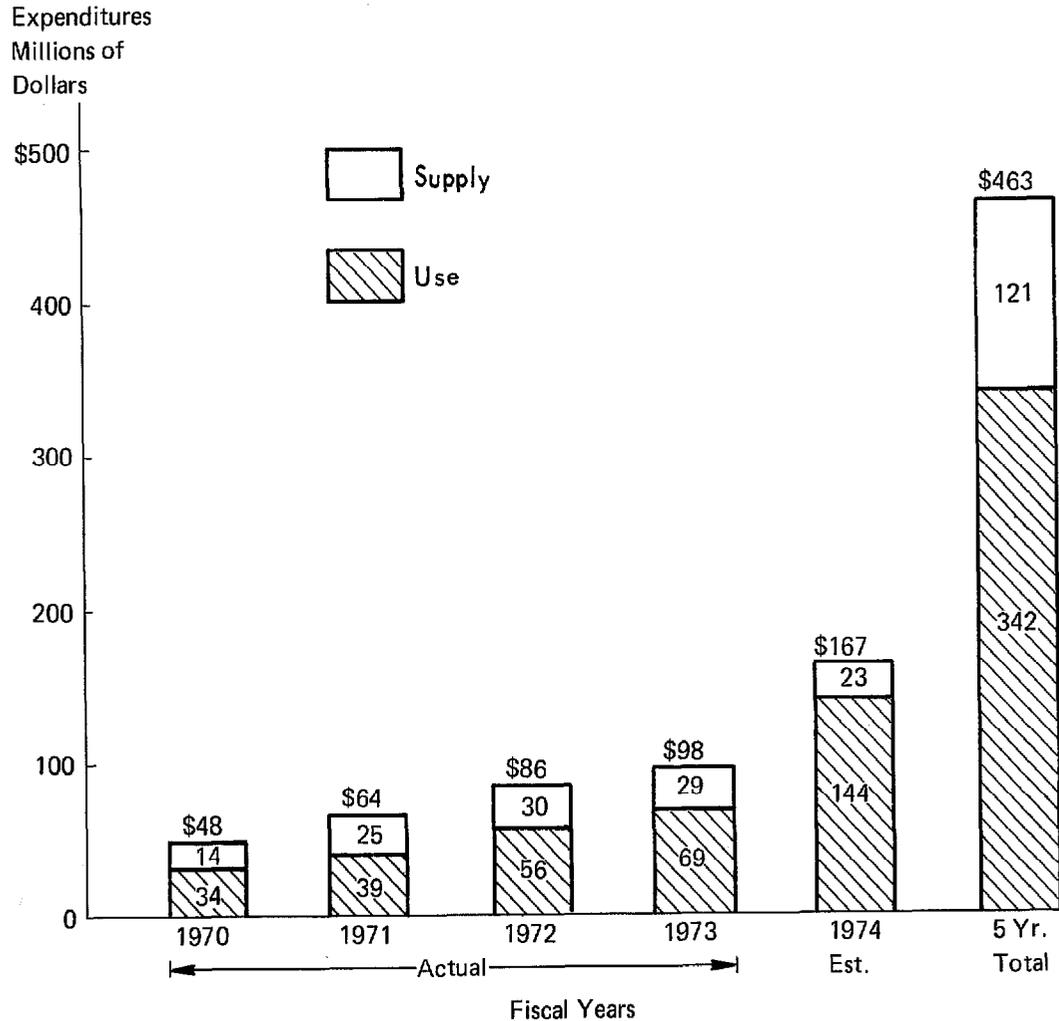
FEA was established in June 1974 to, among other things, (1) advise the President and the Congress with respect to establishing a comprehensive national energy policy in relation to energy matters and integrating domestic and foreign policies relating to energy resource management and (2) assess the adequacy of energy resources to meet demands in the immediate and longer range future for all sectors of the economy and for the general public. Before FEA's establishment, many of the activities for improved management and coordination of Federal energy resources were the responsibility of the Federal Energy Office within the Executive Office of the President.

Although FEA is not involved in coal research, it has carried out activities which could effect coal research. FEA had the lead role in preparing a report on Project Independence. This report evaluates the Nation's energy problems and discusses the impacts and implications of a wide range of energy policy alternatives. It also presents evaluations of constraints on increased energy supply, environmental considerations, and economic and social impacts. The findings of the report on Project Independence with respect to coal research are discussed in chapters 3 and 4.

RESEARCH FUNDING

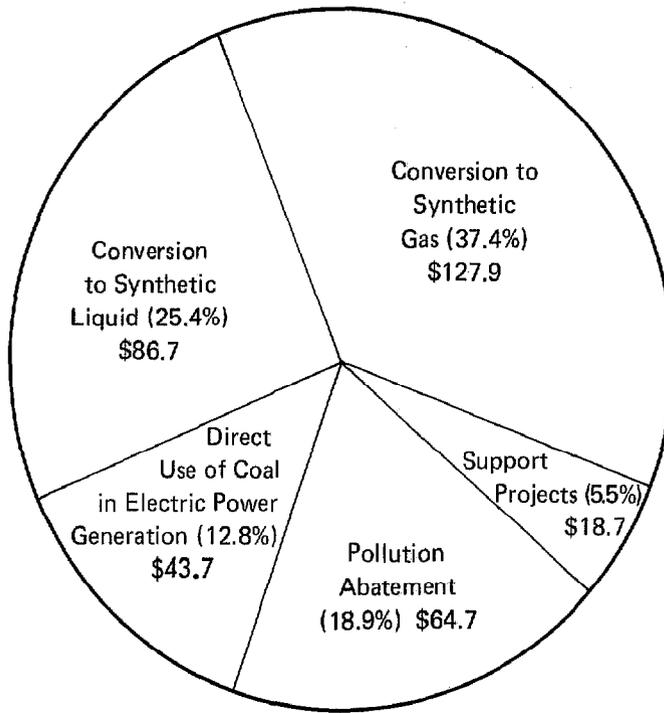
During recent years, coal use research has been the main thrust of the overall coal research of the Federal agencies. Actual research expenditures for fiscal years 1970 through 1973 and the estimated expenditures for fiscal year 1974 totaled about \$463 million. Of this amount, about \$342 million, or 74 percent, was used for coal supply research, as shown below.

**COAL USE AND COAL SUPPLY
RESEARCH EXPENDITURES FISCAL YEARS 1970 - 1974**

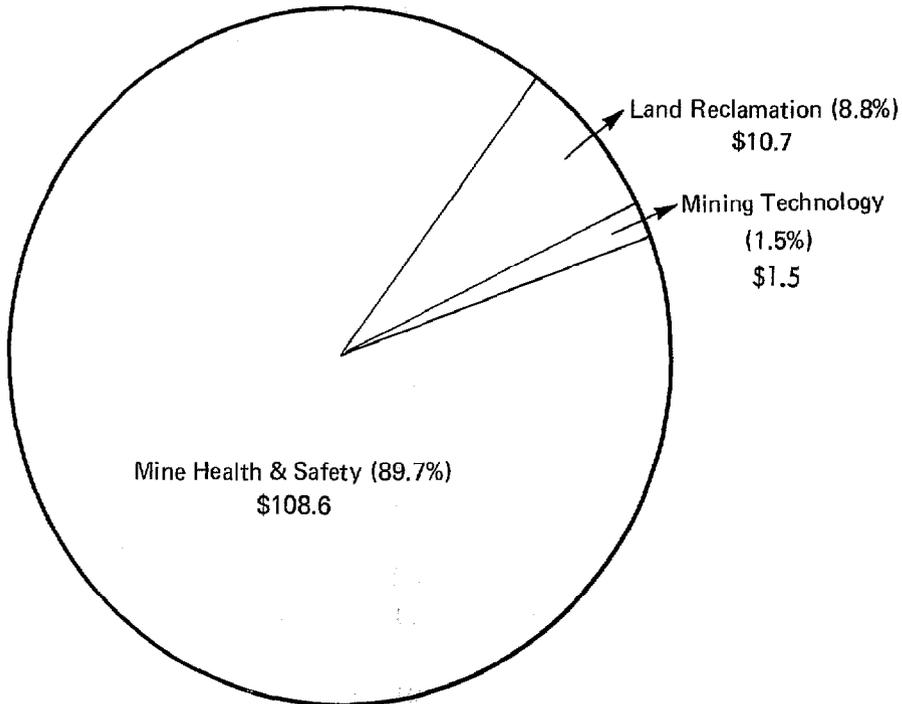


Coal use research has emphasized converting coal to synthetic gas. About 90 percent of the coal supply research funds had been spent on mining health and safety. Actual expenditures for various broad categories of coal use research and coal supply research from fiscal year 1970 through fiscal year 1973 and estimated expenditures for fiscal year 1974 are shown on the following page.

**COAL USE RESEARCH, FY 70 - FY 74 = \$341.7
(\$ MILLIONS)**



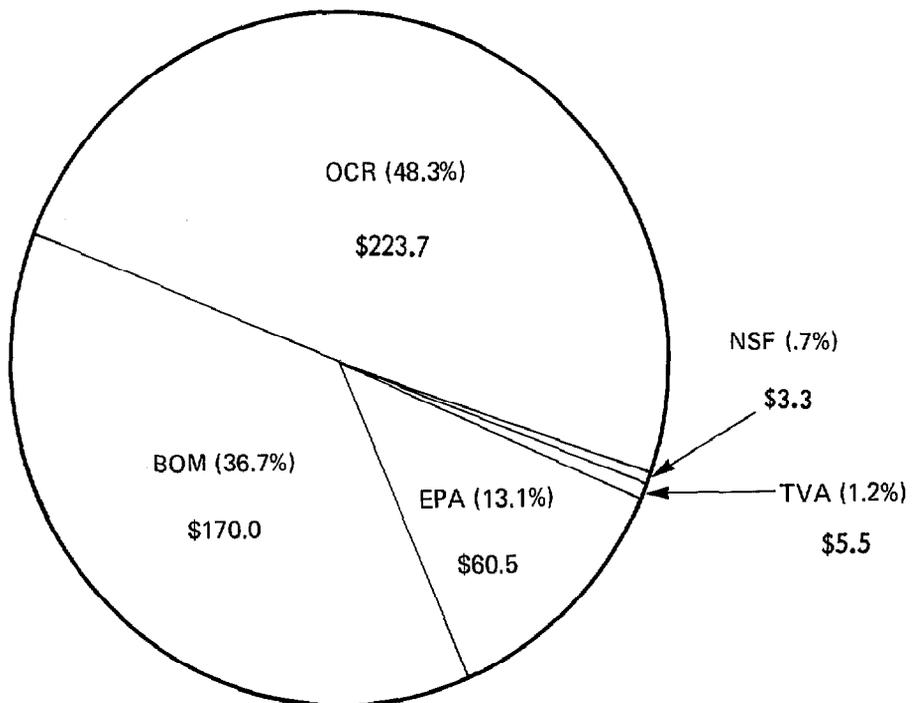
**COAL SUPPLY RESEARCH, FY 70 - FY 74 = \$120.8
(\$ MILLIONS)**



Private industry has also contributed to the funding of Federal coal research by cosponsoring coal use research projects with OCR. From fiscal year 1970 through fiscal year 1973, private industry provided about \$6.5 million for approximately 20 projects.

Although OCR, BOM, EPA, TVA, and NSF are all involved in coal research, OCR and BOM provide most of the funding. The agencies' actual research expenditures for fiscal years 1970-73 and the estimated expenditures for fiscal year 1974 totaled about \$463 million. Each agency's expenditure is shown below.

FEDERAL COAL RESEARCH EXPENDITURES
FY 1970 - FY 1974
(\$ MILLIONS)



Since fiscal year 1970, OCR and BOM primarily have funded research for converting coal to synthetic gas and oil, whereas OCR and EPA have funded most of the research in the direct use of coal in power generation. EPA primarily has funded pollution abatement research. BOM has funded almost all coal supply research. These expenditures are shown below.

Coal Research Expenditures
Fys 1970-74

<u>Research category</u>	<u>BOM</u>	<u>OCR</u>	<u>EPA</u>	<u>TVA</u>	<u>NSF</u>	<u>Total</u>
	----- (millions) -----					
Coal use research:						
Conversion to synthetic gas	\$ 26.2	\$100.1	\$ 0.4	\$ -	\$1.4	\$128.1
Conversion to synthetic oil	5.3	80.0	-	-	1.1	86.4
Direct use in power generation	4.1	29.6	9.8	0.1	.1	43.7
Pollution abatement	10.5	1.7	48.9	3.6	.1	64.8
Support research	5.3	12.0	1.2	.1	.6	19.2
Total	<u>51.4</u>	<u>223.4</u>	<u>60.3</u>	<u>3.8</u>	<u>3.3</u>	<u>342.2</u>
Coal supply research:						
Mining technology	1.0	.3	.2	.0	.0	1.5
Land reclamation	9.0	.0	.0	1.7	.0	10.7
Mine health and safety	<u>108.6</u>	<u>.0</u>	<u>.0</u>	<u>.0</u>	<u>.0</u>	<u>108.6</u>
Total	<u>118.6</u>	<u>.3</u>	<u>.2</u>	<u>1.7</u>	<u>.0</u>	<u>120.8</u>
Total	<u>\$170.0</u>	<u>\$223.7</u>	<u>\$60.5</u>	<u>\$5.5</u>	<u>\$3.3</u>	<u>\$463.0</u>

NON-FEDERAL COAL RESEARCH

Coal research is also being done by private industry, State governments, academic institutions, and foreign countries. However, the significance, extent, and relationship of this research to Federal research is difficult to determine because (1) no formal means exist for obtaining this

information from various sources and (2) non-Federal sources are reluctant to disclose research information which they consider to be proprietary. These matters are discussed below.

Non-Federal domestic research

Many oil, coal, and utility companies; State governments; academic institutions; and others have conducted or are conducting coal research. For example, a January 1974 edition of a House Committee on Science and Astronautics report, entitled "An Inventory of Energy Research," identified 167 coal-related research projects being made by non-Federal private organizations, of which 47 indicated some Federal sponsorship. The overall cost of these projects was not shown, however, and the relationship of this research to Federal coal research was not indicated. Also, the report noted that the inventory might not be complete because of the vast amount of research being done by large industrial corporations and because the cost of answering questionnaires when many research projects are involved.

Private industry and others were researching coal use.

--In 1973 a major oil company announced a \$10 million commitment to intensify its work on developing processes to convert coal to synthetic gas and oil. The company stated that since 1966 it spent about \$20 million on coal research.

--In 1971 six utility and energy companies announced a joint venture for developing a process to convert coal to synthetic oil. About \$32 million was expected to be spent for developing the process, and the commercial plant ultimately to be constructed was estimated to cost over \$250 million.

We were unable, however, to obtain definitive information on all private coal research because there was no formal means for obtaining such information from the various sources. Federal agency officials involved in coal research told us that they relied on program managers' and researchers' personal knowledge of private research and that there was no formal means for obtaining this information. Also, representatives of private companies involved in coal research told

us that they were reluctant to reveal the extent of their research or the level of technology developed because of the proprietary nature of the information.

Foreign research

A large amount of coal research is also being done by the mining industries and the governments of foreign countries. A report on coal research in Western Europe presented to the International Coal Research Conference in October 1973, estimated the expenditures for coal research in Belgium, France, West Germany, and the United Kingdom during 1972 at about \$67 million. The report also noted that such research included work in the areas of underground operations, product beneficiation (desulfurization and water and ash removal), coal use, environmental aspects, and mine safety.

A similar report to the 1973 International Coal Research Conference by the Canadian Department of Energy, Mines, and Resources indicated a considerable amount of research was being done by the Canadian Federal Government, Provincial governments, and energy resource companies in the areas of mine environment improvement, coal beneficiation, land reclamation, transportation, and the conversion of coal to synthetic gas. The report did not, however, indicate the level of research or the estimated total expenditures.

Research in the direct use of coal in electric power generation has also been undertaken in the Soviet Union and Japan. In October 1972, a team of United States scientists visited the Soviet Union under the auspices of the Office of Science and Technology and reported that a Soviet pilot plant for the direct use of coal in electric power generation was able to produce electric power output for a limited time. Also, in August 1972, the Japanese Government announced the allocation of \$80 million for a 7-year period to construct a pilot plant for the use of coal in electric power generation.

An information exchange agreement is in effect between the Department of the Interior and the National Coal Board of Great Britain, and there have been exchanges of technical personnel between BOM and the staffs of British, German, and Polish research installations. Also, the Department is

developing additional formal instruments for information exchange with other countries and there is an active professional exchange of information through national and international meetings.

We believe that additional international research information exchange agreements would be useful. Also, while we agree that staff exchanges and participation in national and international professional meetings are useful, we believe that more formal procedures for exchanging and disseminating coal research information are needed. As with private research efforts in the United States, we were unable to obtain information on foreign research efforts and the relationship of these efforts to coal research efforts conducted by the Federal Government because there is no formal means for obtaining and disseminating such information.

ANTICIPATED FUTURE RESEARCH

In December 1973, the Chairman of the Atomic Energy Commission issued a report to the President, in response to his June 1973 directive, on an integrated national energy research and development program. The report stated that present energy problems stemmed from a lack of a centrally directed and coordinated energy research and development program over the past 20 years. The report stated also that the United States had the resources and technology for energy self-sufficiency and that, with a concentrated research effort, energy self-sufficiency could be expected by 1985.

The report recommended an accelerated research and development effort of \$10 billion of Federal funds for 5 years beginning in fiscal year 1975, coupled with the establishment of an Energy Research and Development Administration to plan and coordinate the total energy program and to direct the major share of the Federal program. Of the \$10 billion recommended for energy research, about \$2.2 billion would be directed toward research to substitute coal for oil and gas on a massive scale. Of the remaining \$7.8 billion, over half would be directed to research on nuclear energy. Other energy sources, such as oil shale and geothermal energy, would also receive increased funds for research.

The report further recommended that the \$2.2 billion for coal research be directed, as shown below.

	<u>Amount</u> (000,000 omitted)
Coal use research:	
Conversion to synthetic gas--continue research into technologies to convert coal to gas through constructing and operating pilot and demonstration plants.	\$ 540
Conversion to synthetic oil--continue research into technologies to convert coal to oil through constructing and operating pilot plants.	375
Direct use of coal in electric power generation--continue research by constructing and operating pilot and demonstration plants.	200
Pollution abatement--develop advanced processes to remove undesirable emissions and dispose of undesirable by-products resulting from direct coal combustion.	260
Synthetic fuels pioneer program--assist private industry in constructing commercial plants based on existing technology by investigating, testing, and disseminating research findings and by establishing engineering performance, benchmarks, economic parameters, and environmental aspects of commercial operations.	355
Support projects--research equipment and supply needs for commercialization of conversion processes.	<u>120</u>
	1,850

Coal supply research:

Mining technology--develop and test coal-mining techniques to increase productivity and recovery rates and to meet environmental and health standards.

325

Total

\$2,175

The report was discussed at hearings before the Joint Committee on Atomic Energy during December 1973. The Chairman of AEC testified that the Advisory Council on Energy Research and Development endorsed the recommendations of the report relating to fiscal year 1975. It was further stated that OMB requested that all major agencies involved in energy research amend their budgets to support the recommendations in the report. An OMB official told us that the agencies involved in coal research included about \$566 million for coal research in the fiscal year 1975 budget, compared with about \$167 million in fiscal year 1974.

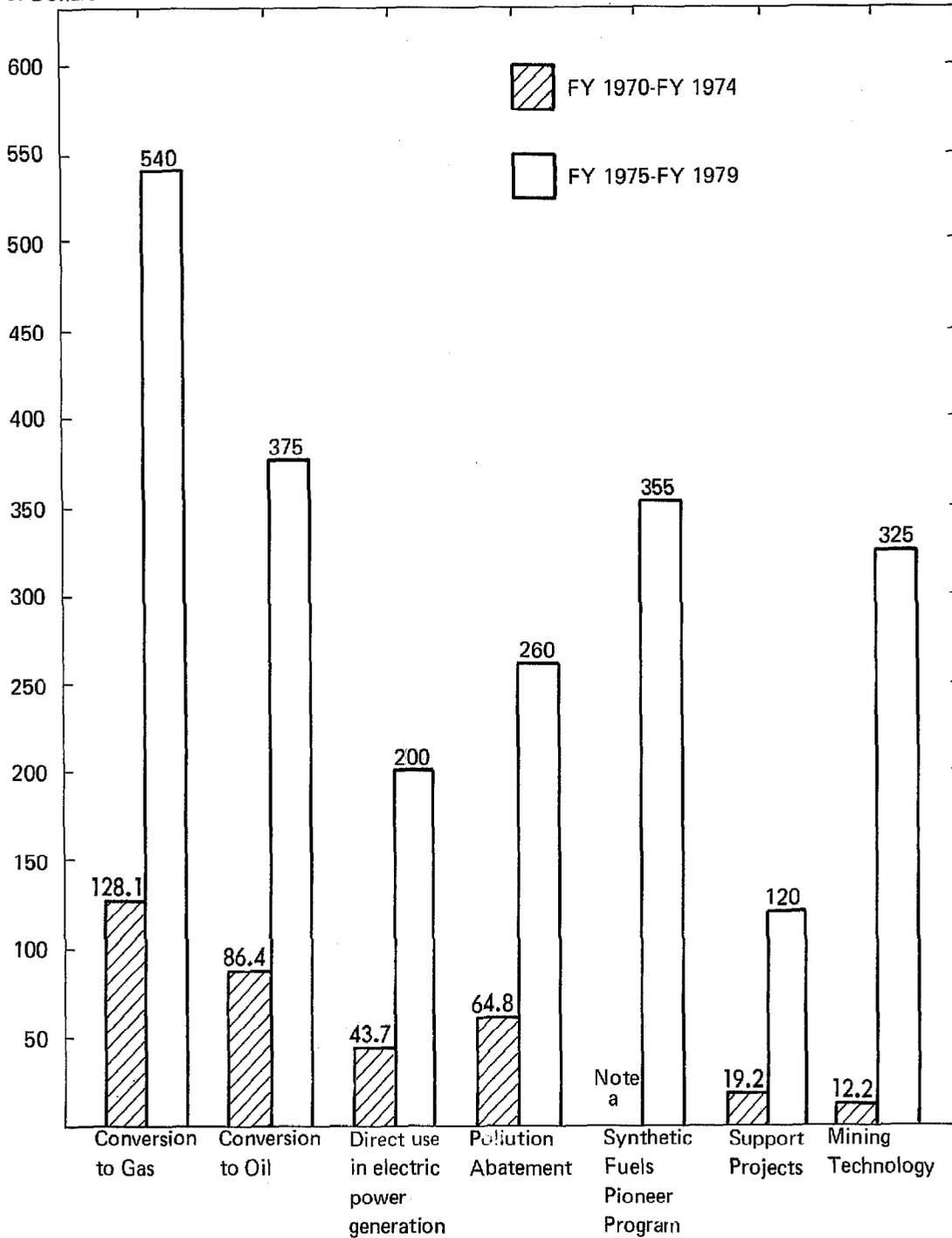
The funding level recommended in the December 1973 report would significantly expand and accelerate coal research programs. The recommended 5-year funding of about \$2.2 billion is about five times greater than the estimated funding for the 5-year period ended in fiscal year 1974. A comparison of past coal research funding with the recommended future funding by various categories is shown on the following page.

To insure that adequate attention is given to the management of the 5-year accelerated energy research and development program, in March 1974 OMB issued a directive designating various agencies as lead agencies in each major program area. For example, AEC was designated lead agency in nuclear fission and the Department was designated lead agency in coal extraction and use and land reclamation. OMB requested that each lead agency prepare a concise Government-wide program planning document for energy research and development. This document is intended to provide a formal description of each energy research and development program and is to include a discussion of

--the overall program goal;

**COMPARISON OF ESTIMATED FEDERAL FUNDING FOR SELECTED COAL
RESEARCH ACTIVITIES – FISCAL YEARS 1970 – 1974
AND FISCAL YEARS 1975 – 1979**

Millions
of Dollars



Note: a – A new program which was not specifically funded in FY 1970-1974 period.

- the specific program objectives;
- the strategy for the 5-year energy research and development program; and
- a program implementation plan including milestones and timetables for completion of research, with particular attention to fiscal year 1975 and tentative fiscal year 1976 plans.

The Department of the Interior's coal research and development planning document was provided to OMB on June 10, 1974. This planning document is intended to serve as the framework for future government-wide coal research and development efforts.

CONCLUSIONS

Until October 1974, when an ERDA was authorized by the Energy Reorganization Act, there had been no focal point for Federal coal research program efforts. The present program evolved over a period of years in response to the specific missions of the primary coal research agencies, with each agency pursuing its own research objectives, priorities, and goals.

Although actions had been taken to strengthen the direction of the Federal coal research efforts--(1) the May 1973 establishment of ORD within the Department of the Interior to direct the Department's research program and the establishment of a unified coal research program within the Department which is intended to provide clearer lines of research responsibilities between BOM and OCR and (2) the designation of the Department of the Interior, by OMB in March 1974, as the lead agency for the development of a concise Government-wide program planning document identifying the research and development goals, objectives, strategies, and implementation plans for coal extraction and utilization and land reclamation--we believe the establishment of ERDA should be a major step in the direction of developing a unified coordinated Federal coal research program.

Also, funding for Federal coal research activities increased significantly during fiscal years 1970-74. Such increases occurred as energy problems became more pronounced

Additional substantial funding increases are anticipated for the 5-year period beginning in fiscal year 1975 in order to maximize the use of our Nation's coal resources and achieve the President's established goal of energy self-sufficiency. We believe that ERDA should be in a position to provide better direction and coordination of energy research and development programs at the Federal level.

Although coal research activities are also being carried out by non-Federal organizations and by foreign countries, the extent of such activities is difficult to determine primarily because of the reluctance of these organizations and countries to disclose proprietary information. We believe that a free and full exchange of such information would be beneficial.

RECOMMENDATIONS

Because a free and full exchange of research and development information between Federal agencies and companies and foreign countries involved in energy research should be of mutual benefit, the Administrator of ERDA, in cooperation with the Department of the Interior, FEA, and other Federal agencies involved in coal research activities, should determine whether procedures can be developed for exchanging research and development information under proper safeguards to avoid public disclosure of proprietary information.

CHAPTER 3

COAL USE RESEARCH ACTIVITIES

During fiscal year 1974, 21 advanced coal use research projects were in various stages of development; 10 were gas conversion projects, 5 were liquid conversion projects, and 6 were electricity conversion projects. Of the 21 projects, 17 had been funded primarily by OCR, 3 by BOM, and 1 by EPA. Federal research officials do not expect Federal research efforts in these conversion processes to produce commercially acceptable processes until the late 1970s or mid-1980s because of insufficiently advanced technologies.

Most advanced coal use projects were in the pilot plant or laboratory stage in fiscal year 1974. Available estimated costs for commercial plants for the advanced projects range from \$100 million a plant for an electricity conversion process capable of producing sufficient gas to power a 1,000 megawatt generator and to provide electricity for about 200,000 homes annually, to \$785 million a plant for a combined oil and gas conversion process which would provide gas and oil to heat over 2 million homes annually.

Federal efforts in pollution abatement research, funded primarily by EPA, have produced six advanced processes to remove pollutants resulting from the direct combustion of coal. These processes are not, however, as efficient or as economical as desired. Estimated costs to install these processes in electrical generation plants range from \$35 to \$43 million for a new 1,000 megawatt plant to \$52 to \$68 million for an existing 200 megawatt plant. Federal research efforts to improve the efficiency and economy of these pollution abatement processes will continue.

A summary of significant Federal coal utilization and pollution abatement research programs follows.

Advanced Coal Conversion and Pollution Abatement Research Activities

<u>Program</u>	<u>Number of major projects</u>	<u>Current status</u>	<u>Estimated commercialization date</u>	<u>Estimated cost per commercial plant or application</u> (000,000 omitted)	<u>Estimated coal use a day</u> (tons)	<u>Estimated plant output and use</u>
Converting coal to gas:						
High Btu gas (a substitute natural gas)	4	All in pilot plant phase	1980s	\$250 to \$400	16,500	250 million cubic feet of gas a day which would heat about 700,000 homes annually
Low Btu gas (a low heat value gas used in electric power generation)	6	One in pilot plant phase Five in laboratory phase	1980s	\$100	11,000	Produce gas for electrical generation which would provide electricity for about 200,000 homes annually
Converting coal to oil and gas	5	Three in pilot plant phase Two in laboratory phase	mid-1980s	^a \$785	^a 57,700	^a 100,000 barrels of oil a day and 330 million cubic feet of gas a day. The gas alone would provide heat for about 900,000 homes annually and the oil would provide heat for about 1,250,000 homes annually.

Program	Number of major projects	Current status	Estimated commercialization date	Estimated cost per commercial plant or application (000,000 omitted)	Estimated coal use per day (tons)	Estimated plant output and use
Direct Use of Coal in Electrical Power Generation:						
Magneto-hydrodynamics (a method of burning coal to generate gas for electric power generation)	4	All in laboratory phase	Mid-1980s	\$250	8,400	Energy to power a 1000 megawatt generator which would provide electricity for about 250,000 homes annually
Fluidized bed combustion (a method of burning coal to generate steam for electric power generation)	2	Pilot plants under construction	Late 1970s	Unavailable	8,400	Steam to power an 800 megawatt generator which would provide electricity for about 200,000 homes annually
Pollution Abatement:						
Stack gas cleanup (cleaning gases resulting from the burning of coal in electric power plants)	6	Demonstration phase	Late 1970s	\$35 to \$43 for new plants \$52 to \$68 for existing plants	Not applicable	Not applicable

^a Estimates are for combined oil and gas (COG) refineries. OCR officials believe processes under development will be adapted to COG concept.

Although Federal funding for coal use research has increased significantly over the past several years and there are prospects for commercialization of various conversion processes, potential problem areas exist which may delay the transition from the research phase to the commercial phase. Research and studies are needed in these areas which include (1) whether private industry will be able to supply the specialized equipment necessary for various conversion processes in the required time frame because of currently limited technology to fabricate and erect such equipment and because of competing demands for similar equipment by other energy sources, such as the nuclear power industry, (2) whether it will be possible to select and establish conversion plant sites promptly enough to insure that such plants are available when needed, and (3) whether private industry will be willing to provide the large capital investment necessary for the construction and operation of conversion facilities because of uncertainty as to the role of coal in meeting future energy demands.

The Project Independence report identified and discussed potential constraints on the development of energy resources, including coal. Although the report discussed alternative ways of resolving some of these potential constraints, it did not mention specific actions. Federal agencies involved in coal research also recognized these potential problems and initiated or planned actions to resolve them.

The status of Federal coal conversion research activities and potential problems in commercialization of conversion processes and agency actions to resolve such matters are discussed below.

STATUS OF COAL USE RESEARCH

Coal use research activities include the conversion of coal to synthetic gas and oil, the direct use of coal in electric power generation, and abating pollution.

From fiscal year 1970 to fiscal year 1974, an estimated \$342 million had been spent on this research.

Converting coal to synthetic gas

Federal research in this area has been sponsored primarily by OCR and BOM. From fiscal year 1970 to fiscal year 1974, an estimated \$128 million was spent on this research. Of this estimated \$128 million, about \$101 million was directed to converting coal to high-Btu gas and about \$27 million for low-Btu gas.

To convert coal to synthetic gas, coal is fed into a high-temperature, pressurized reactor, along with steam and air or oxygen. A chemical reaction occurs and a mixture of gases is produced. The gases produced include carbon monoxide, hydrogen, and methane. Methane is the main constituent of natural gas. The gases are then cooled and undesirable components, such as carbon dioxide and sulfur, are removed.

The raw gas produced at this point is referred to as low-Btu gas. This gas has a low-heat value (less than 450 Btu's) and cannot be economically transmitted by pipeline. It is valuable, however, as a fuel supply for electrical power generation plants near the conversion plant. A low Btu gas conversion process is in commercial use today, which is based on technology developed in Europe about 50 years ago. According to an Oak Ridge National Laboratory report, disadvantages of this process are its high operating and maintenance cost requirements and its inability to use the types of coal found in the developed coal region of the eastern interior and Appalachian regions of the United States. The process is better suited to the use of coals found in the undeveloped coal regions of the Western United States.

Low-Btu gas can be upgraded to a high-Btu gas (950 plus Btu's) through a process of adding additional hydrogen to the gas, referred to as methanation. High-Btu gas is a substitute for natural gas and can be transmitted in existing networks of pipelines to satisfy the demands of present users of natural gas. The Federal high-Btu and low-Btu gas research programs are discussed below.

High-Btu gas research program

Federal research in this area is directed toward development of four different advanced processes to demonstrate

the feasibility of producing pipeline quality synthetic gas from coal. The processes are similar in that each produces high-Btu gas, but each process employs a somewhat different method of producing the gas.

Before fiscal year 1972, both OCR and BOM funded various high-Btu gas research projects. Beginning in fiscal year 1972, however, the program received increased emphasis when OCR and the American Gas Association (AGA) entered into an agreement to jointly sponsor a \$120 million research and development program over a 4-year period. Under the agreement's terms, OCR is to provide \$80 million and AGA \$40 million for three conversion processes.

The ultimate objective of this program is to design, construct, and operate a demonstration plant which will serve as a prototype for commercial application. The program calls for a four-phase research and development effort.

- Development, design, and operation of several small-scale laboratory or process development units.
- Design, construction, and operation of medium-size pilot plants.
- Design, construction, and operation of a demonstration plant based on the best features of the individual pilot plants.
- Design of a commercial plant.

Because of the 1971 agreement between OCR and AGA, research efforts to convert coal to high-Btu gas were accelerated. Pilot plants for two of the processes are operational and the third pilot plant is under construction.

In addition to the three OCR/AGA processes, BOM independently funded and developed a different process to convert coal to high-Btu gas. The pilot plant for the BOM process is under construction.

Information on the three OCR/AGA processes and the BOM process follows.

Summary of Advanced High-Btu Processes

<u>Process name</u>	<u>Federal agency sponsor</u>	<u>Industry cosponsor</u>	<u>Contractor</u>	<u>Estimated funding to 6-30-74</u>			<u>Process phase</u>		<u>Estimated total cost (millions)</u>
				<u>Federal</u>	<u>Other</u>	<u>Total</u>	<u>Description</u>	<u>Estimated completion date</u>	
				<u>(millions)</u>					
HYGAS	OCR	AGA	Institute of Gas Technology	\$ 9.8	\$6.7	\$16.5	Pilot plant in operation	1976	\$63.5
BI-GAS	OCR	AGA	Bituminuous Coal Research, Inc.	18.1	7.1	25.2	Pilot plant under construction; scheduled for completion in early 1975	1977	45.0
CO ₂ ACCEPTOR	OCR	AGA	Consolidation Coal Company	20.7	5.6	26.3	Pilot plant in operation	1976	31.5
SYNTHANE	BOM	None	Rust Engineering	19.1	-	19.1	Pilot plant under construction; scheduled for completion in late 1974	1975	21.7

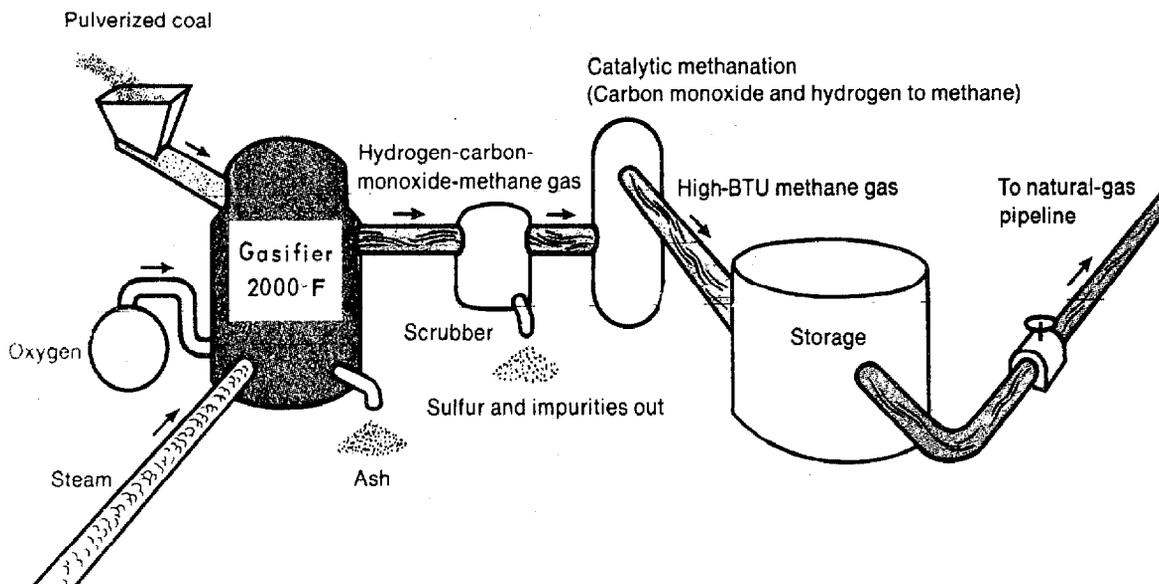
The pilot plant phase of the high-Btu gas program is expected to be completed by 1977. This phase is designed to yield data on the effectiveness of each of the four conversion processes and any problems experienced in the operation of the pilot plants.

Information developed in the pilot plant phase on the three OCR/AGA processes and the BOM process is being evaluated by a professional engineering firm under contract to OCR. This firm will evaluate and compare the technical results and economic feasibility of each of the high-Btu gas processes and recommend designs for a demonstration plant. The demonstration plant would provide the economic data necessary to establish the economic feasibility of the process and the engineering data required for construction of a full commercial plant.

The program's demonstration phase is expected to begin in 1975 and it is estimated that a demonstration plant can become operational by about 1979. OCR hopes for commercial application of a high-Btu gas plant by the early 1980s. The commercial plants ultimately to be constructed are each expected to consume about 16,500 tons of coal a day and produce about 250 million cubic feet of pipeline-quality gas each day; sufficient to heat about 700,000 homes annually. OCR and AGA estimate that a commercial plant will cost about \$250 to \$400 million to construct.

An illustration of a high-Btu gas process is shown below.

HIGH-BTU GAS



Low-Btu gas research program

Although BOM conducted research on converting coal to low-Btu gas as early as 1948, it was not until fiscal year 1973 that increased emphasis in terms of funding occurred. In 1973 OCR initiated a research and development program to demonstrate the feasibility of producing a clean low-Btu gas for use as fuel by the electric utility industry for electrical generation plants.

The major emphasis of the low-Btu program is directed to the parallel development of six different conversion processes. Each process employs a different method of converting coal to low-Btu gas and of removing impurities in the gas.

Five of the six processes were sponsored by OCR and were at various stages of development leading to construction of pilot plants. The pilot plant for one process is currently under construction and the pilot plant for another was scheduled for construction during 1974.

A small pilot plant for one process was developed and operated by BOM at one of its research centers. BOM exclusively funded development of this process through 1974. Research has progressed to a stage where plans now call for the process to be tested at a utility plant. OCR has assumed responsibility for this phase, which will include TVA's participation. The smaller BOM plant is expected to continue operating in a research-support capacity. The participating agencies estimate that about \$15 million will be provided over a 4-year period to design, construct, and operate a larger pilot plant to generate low-Btu gas as fuel for a TVA electrical power generation facility.

Information on the low-Btu processes is shown on the following page.

The pilot plant phase of the low-Btu gas program is expected to continue until about 1979. Technical and economic data developed during this phase was evaluated by a professional engineering firm under contract to OCR and used to prepare a preliminary design for demonstration plants based on the best features of the various pilot processes.

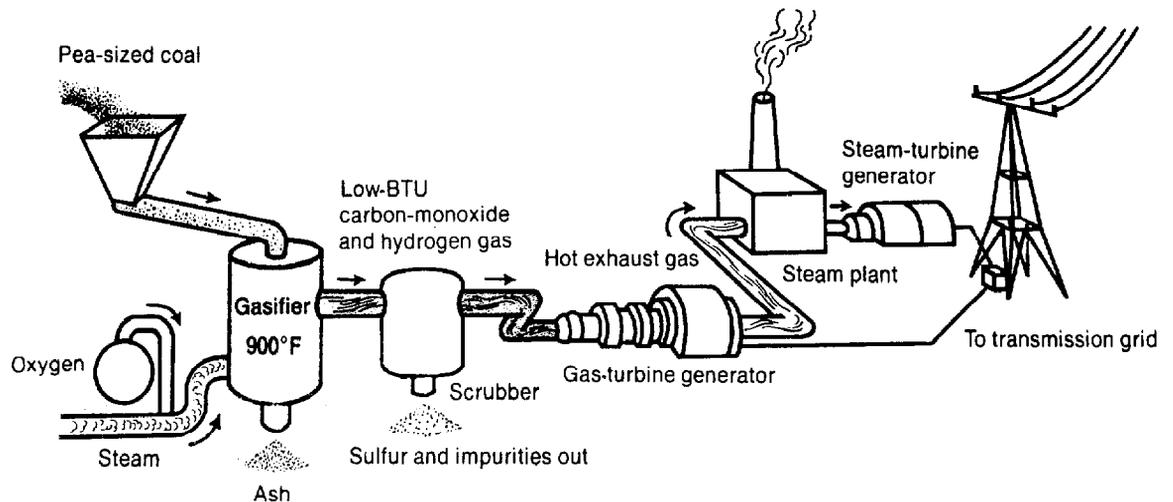
Summary of Low-Btu Processes

Process name	Federal agency sponsor	Industry cosponsor	Contractor	Estimated funding to 6-30-74			Description	Process phase Estimated completion date	Total estimated cost (millions)
				Federal	Other	Total			
Stirred Fixed Bed Gas Producer	OCR BOM TVA	To be selected	BOM Research Center, Morgantown, W.Va.	\$3.7	None	\$3.7	Process development unit in operation	1981	\$32.0
Entrained Bed Gasifier	OCR	Foster, Wheeler, Corp; Pittsburg & Midway Coal Mining Co., and Northern States Power Co.	Same as cosponsors	.5	None	.5	Contract investigation to be completed in 1978	1978	69.0
Entrained Bed Atmospheric Gasification System	OCR	Combustion Engineering, Inc. Consolidated, Edison of New York	Same as cosponsors	.15	.15	.3	Contract under negotiation for the design, construction, and operation of a process development unit	(a)	27.2
Fluidized Bed Pressure Gasification System	OCR	Westinghouse Electric Corp.; Public Service of Indiana. Amax Coal Co.; Bechtel Corp.; and Peabody Coal Co.	Same as cosponsors	5.7	2.5	8.2	Process development unit is being tested	1981	25.0
High Temperature Gas Clean-up Using Dolomite	OCR	None	Air Products and Chemicals, Inc.	.5	None	.5	Laboratory experiments continuing	1975	.5
High-Temperature Cleanup with molten salt	OCR	None	Battelle Memorial Institute Pacific Northwest Laboratories	.4	None	.4	Design of a pilot plant in progress	1974	4.0

^aContract under negotiation as of Aug. 15, 1974. Estimated total cost for current phase not available.

The demonstration phase is expected to continue until about 1980 after which OCR anticipates commercial application of a low-Btu gas process. Commercial plants ultimately to be constructed are expected to cost at least \$100 million a plant. A 1,000 megawatt commercial low-Btu plant is expected to consume about 11,000 tons of coal a day and provide fuel to generate sufficient electricity for about 200,000 residences annually. An illustration of low-Btu gas process in conjunction with an electrical power generation plant is shown below.

LOW-BTU GAS FOR ELECTRIC POWER GENERATION



Converting coal to synthetic liquid fuels

From fiscal years 1970 through 1974, an estimated \$87 million had been expended on 48 projects, primarily by OCR and BOM. NSF supported OCR's and BOM's research efforts from about fiscal year 1973, by sponsoring research with major academic institutions involving certain specialized aspects of the conversion program.

The major Federal efforts in this area are directed to the development of five advanced processes to convert coal to synthetic liquid fuels. The processes differ; some burn coal, condense the resulting gases, and add hydrogen

to form a liquid, whereas others process chemically dissolved coal with hydrogen to form a liquid. All involve high temperatures and some involve high pressures.

Technology for converting coal to synthetic liquid fuels was developed in Germany over 60 years ago. Commercial operations, started in Germany in the 1930s, expanded and accelerated with the onset of World War II. Although BOM conducted laboratory tests of German processes to convert coal to liquid fuels from 1918 on, it was only after World War II, when the extent and details of German operations became known, that United States interest in the processes was renewed.

In accordance with the Synthetic Liquid Fuels Act of 1944 (30 U.S.C. 321), BOM conducted a wide variety of research based on its previous work and newly available German information. From 1947 to 1953, BOM designed, built, and operated a pilot plant based on German technology. The efforts were abandoned, however, because the high investment and production costs were not at that time offset by environmental and energy shortage concerns, and because the discovery of large new reserves of petroleum eliminated the wartime incentive for finding a petroleum substitute.

Federal research efforts were renewed with the creation of OCR in 1961. From 1962 to 1970, OCR spent about \$35 million researching different processes to convert coal to liquid fuels. Research on one of the processes, H-coal, was terminated in 1967 at the Government's convenience because of a lack of funds. However, private companies have continued to work on the process and OCR support was reactivated in fiscal year 1974. Research on a second process designed to produce gasoline from coal, Project Gasoline, was suspended in 1970, after the process had reached the pilot plant phase, because of equipment problems. In fiscal year 1975, OCR plans to reactivate its research efforts to modify the existing pilot plant for material development and production of low-sulfur fuel oil from coal for power generation. OCR research efforts on the two remaining processes, Char-Oil Energy Development and Solvent Refined Coal, were continued through the fiscal year 1970-74 period.

During fiscal years 1970-74, BOM also funded research at one of its energy research centers to develop a liquid

conversion process called synthoil. This process is not as far advanced as OCR processes and currently consists of a laboratory unit. In fiscal year 1975, BOM plans to construct a process development unit, which is in effect a small pilot plant, for this process. An OCR official said that if research on the process progressed to the advanced pilot plant stage, OCR would assume responsibility.

Information on the four OCR-sponsored processes and the BOM process is shown on the following page.

All liquid fuel processes have the objective of producing synthetic liquid fuels at prices competitive with natural supply sources. Although each process is unique in its approach to achieving its objective, they are somewhat interrelated and share some of the same technical problems. A technological breakthrough in one of the processes could have a beneficial effect on the other processes.

OCR's liquid fuel program was being evaluated by a professional engineering firm. This firm was evaluating the performance of various pilot plants and other research operations and was developing a conceptual design and economic evaluation for a demonstration plant. OCR plans to complete the design for a demonstration plant for one of the processes in 1975 and to construct and operate the plant by 1978. OCR did not, however, anticipate commercialization of any of the processes before the mid-1980s.

OCR officials believe that the commercial plants ultimately to be constructed will be combined oil and gas plants, called coal-oil-gas (COG) refineries. Based on preliminary conceptual designs, a COG refinery would consume about 57,000 tons of coal a day and produce about 330 million cubic feet of pipeline-quality gas and about 100,000 barrels of a synthetic crude oil a day. Investment in a COG refinery could be as high as \$785 million.

An illustration of a COG refining process is shown on page 47.

Direct use of coal in electric power generation

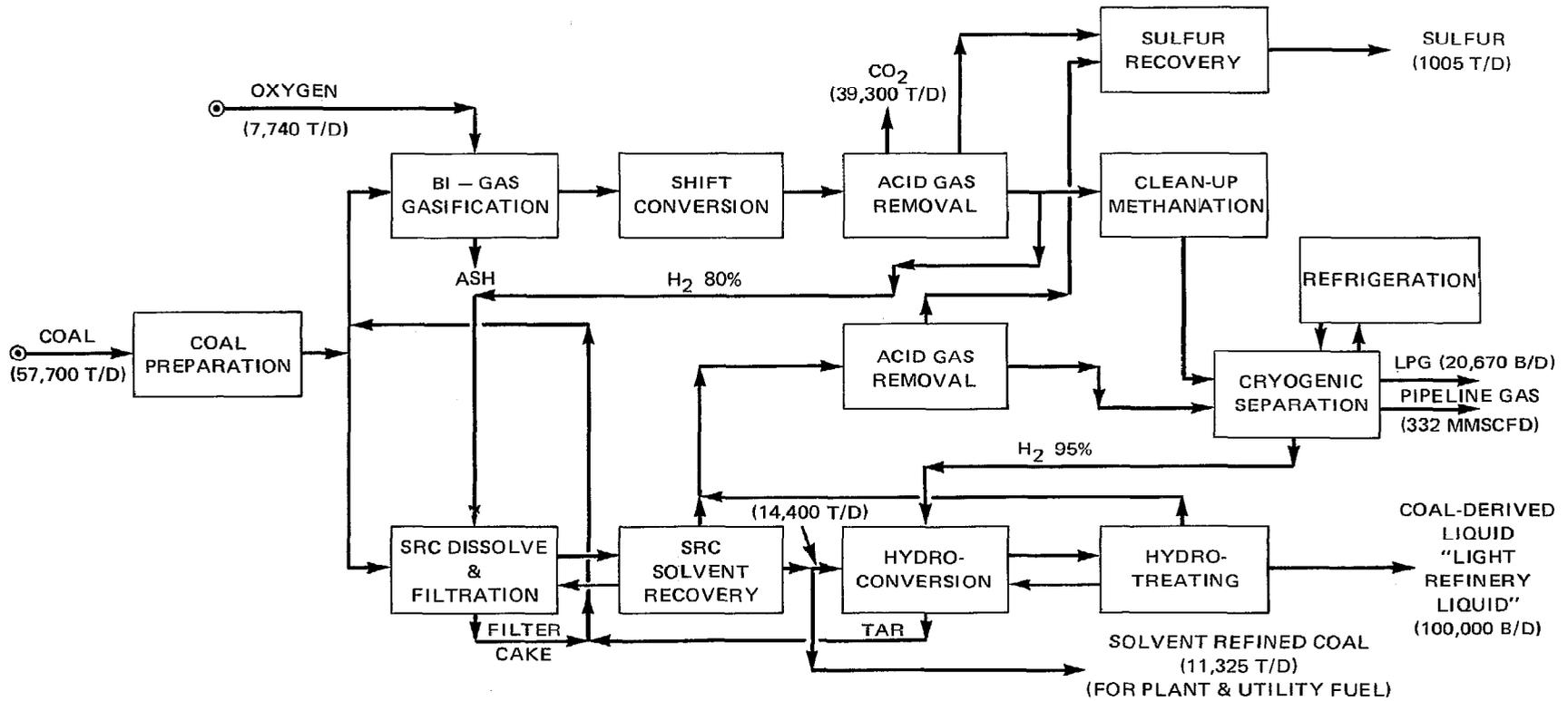
OCR sponsored the primary Federal research efforts in this area. An estimated \$44 million had been expended on

Summary of Advanced Liquid Conversion Processes

Process name	Federal agency sponsor	Industry cosponsor	Contractor	Estimated funding to 6-30-74			Process phase Description	Estimated completion date	Estimated total cost (millions)
				Federal	Other	Total			
Char-Oil Energy Development (COED)	OCR	None	FMC Corporation	\$ 9.0	NONE	\$9.0	Pilot plant in operation	1974	\$21.4
Solvent Refined Coal (SRC)	OCR	None	Pittsburg & Midway Coal Mining Company	28.2	NONE	28.2	Pilot plant scheduled for preliminary testing in 1974	1976	29.7
Multi-process Plant (formerly Project Gasoline)	OCR	Fluor Corp., Allegheny Power and American Electric Power Company	Fluor Corporation	11.3	2.2	13.5	Pilot plant operated 1967-70 under Project Gasoline. Scheduled to be re-activated in 1975 as a component and process test facility	1979	13.0
H-Coal	OCR	Five co-sponsors	Hydrocarbon Research, Inc.	5.4	.3	5.7	Design and construction of pilot plant	1979	75.0
Synthoil	BOM/OCR	(a)	BOM Pittsburgh Energy Research Center	2.3	NONE	2.3	Large laboratory model being developed	1976	4.5

^aAs of November 1974 a contract was being negotiated for cosponsorship of this process.

COAL-OIL-GAS (COG) REFINING PROCESS



47

Source: Chemical Engineering Progress March 1973 p. 62.

LEGEND:

T/D	— tons per day	LPG	— liquified petroleum gas (propane, butane)
B/D	— barrels per day	MMSCFD	— million standard cubic feet per day
H ₂	— hydrogen		
CO ₂	— carbon dioxide		

approximately 60 projects from fiscal year 1970 through fiscal year 1974. The objective of Federal research in the direct use of coal in electric power generation is to develop more efficient methods of generating electricity through use of coal without polluting the environment with undesirable emissions.

In a conventional steam-coal plant, heat energy of coal is converted to steam which is then delivered to a steam turbine to drive an electrical generator and produce electricity. This method is very inefficient, however, and creates a lot of wasted energy in the form of heat which is discharged into the atmosphere and into bodies of water.

The two major efforts in the direct use of coal in electric power generation are discussed below.

Magnetohydrodynamics research program

Magnetohydrodynamics (MHD) involves burning coal under high pressure conditions and forcing resulting gases through a duct at high velocities. The gases in the duct move through a magnetic field surrounding the duct resulting in the generation of electricity. This concept is expected to result in higher efficiency than conventional coal-fired generating plants.

Federal expenditures on MHD research from fiscal year 1970 through fiscal year 1974 are estimated at about \$13 million. Little research was undertaken in this area before fiscal year 1972. Since 1972 OCR entered into several contracts with educational institutions, private industry, and other Federal agencies to study potential problem areas of MHD. Information on four MHD projects is given on the following page. Each project is intended to explore different problems of the MHD concept. OCR said that it and EPRI had prepared a draft of a national plan to develop MHD to the point of commercial application if technical objectives can be met.

OCR anticipated that information developed from its current MHD research efforts would enable it to design, develop, and construct pilot plants to further test the concept by 1979. Technical and economic data developed in the pilot plant phase will be evaluated by a professional engineering firm under contract with OCR and a demonstration plant resulting from this effort is expected to be built in 1981.

Summary of Advanced Magnetohydrodynamics Projects

Project name	Federal agency sponsor	Industry cosponsor	Contractor	Estimated funding to 6-30-74			Description	Process phase	Estimated total cost (millions)
				Federal	Other	Total		Estimated completion date	
MHD Direct Energy Conversion	OCR/TVA	University of Tennessee Space Institute	Same as co-sponsor	\$1.2	\$0.2	\$1.4	Develop basic aspects of MHD for direct combustion of coal	1974	\$1.4
MHD Power Generation	OCR	AVCO	Same as co-sponsor	3.1	2.5	5.6	Conduct MHD generator tests	1974	5.6
Clean Power Generation from coal	OCR	Westinghouse Electric Corp.	Same as co-sponsor	1.0	0	1.0	Study material problems and associated MHD concepts	1975	5.7
Three-stage combustion for MHD Power Generation	OCR/BOM	None	BOM	1.2	None	1.2	Construct a small high-temperature combustion unit	1975	2.3

OCR anticipates eventual commercialization of the MHD concept by the late 1980's or 1990. An MHD commercial plant is expected to consume about 8,400 tons of coal a day and produce sufficient energy to power a 1,000 megawatt electrical generation plant, capable of providing the annual electricity requirements for over 200,000 residences. OCR estimates the construction cost of a commercial MHD plant at about \$250 million.

An illustration of an MHD conversion process is shown on the following page.

Fluidized bed combustion research program

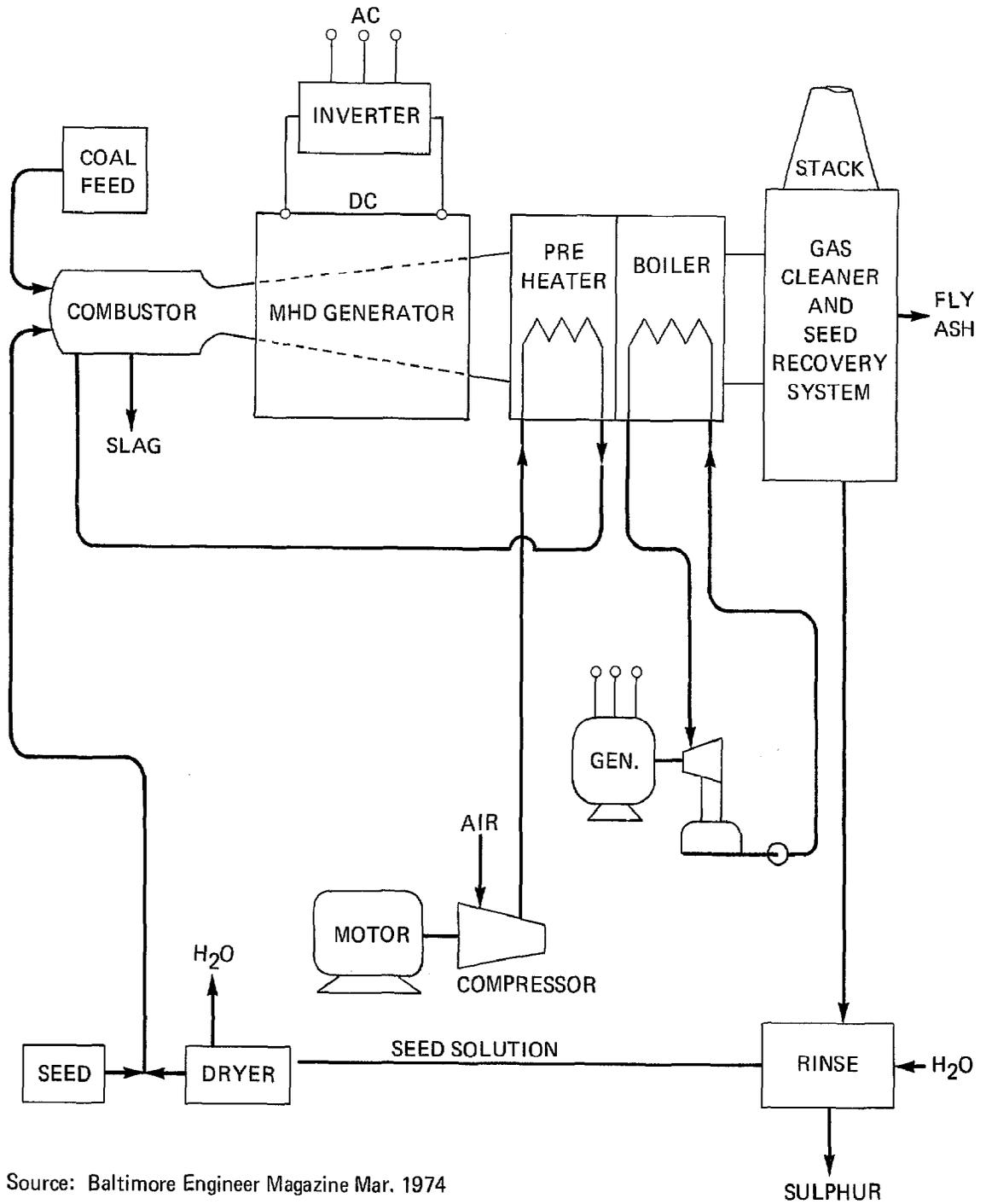
OCR and EPA have funded the primary research efforts in this area. Expenditures for this research for fiscal years 1970-74 are difficult to determine because the concept is applicable to other coal conversion programs and has been studied in connection with these programs.

In the fluidized bed combustion process, small pieces of coal mixed with limestone are fed into a chamber along with hot air. The coal burns and boils water, producing steam to generate electricity. The sulfur in the coal is captured in the limestone and removed with the ash as sulfate. This process results in more efficient power generation than the conventional coal-fired generating plants and removes or minimizes undesirable pollutants.

EPA has conducted research in fluidized bed combustion which resulted in the operation of a pilot plant during fiscal year 1974. Data obtained from the pilot plant's operation will be used for further research efforts.

OCR fluidized bed combustion research efforts before fiscal year 1973 were directed primarily to studies on improving the efficiency of the process. In fiscal year 1973, however, OCR's program received increased emphasis when OCR awarded a 4-year, \$5.8 million contract for the design, construction, and operation of a fluidized bed combustion pilot plant for use by the electric utility industry. The contract was subsequently increased to \$12 million. The ultimate objective of OCR's program was to demonstrate the commercial feasibility of the process.

MHD CONVERSION PROCESS



Source: Baltimore Engineer Magazine Mar. 1974

LEGEND:

H₂O - water
H₂ - hydrogen
GEN - generator
DC - direct current
AC - alternating current

An OCR official told us that ongoing and planned efforts of the agencies involved in fluidized bed research would be combined into a single national fluidized bed combustion program. The overall objective will be the early development, demonstration, and commercialization of fluidized combustion processes. OCR was to be the lead agency for the program. The program is still in the formation stages with detailed plans, goals, costs, and timetables yet to be established and negotiated. Information on the two major OCR and EPA fluidized bed processes is shown on the following page.

OCR believes that the fluidized bed combustion process offers the best prospect for providing large volumes of clean energy from coal at the earliest date. OCR anticipates the design, construction, and operation of a pilot plant by fiscal year 1977. A commercial plant is expected to consume about 8,400 tons of coal per day and to produce sufficient steam to power a 1,000 megawatt electrical generation plant capable of providing the electricity needs for about 200,000 residences. An illustration of a fluidized bed conversion process is shown on page 54.

Pollution abatement

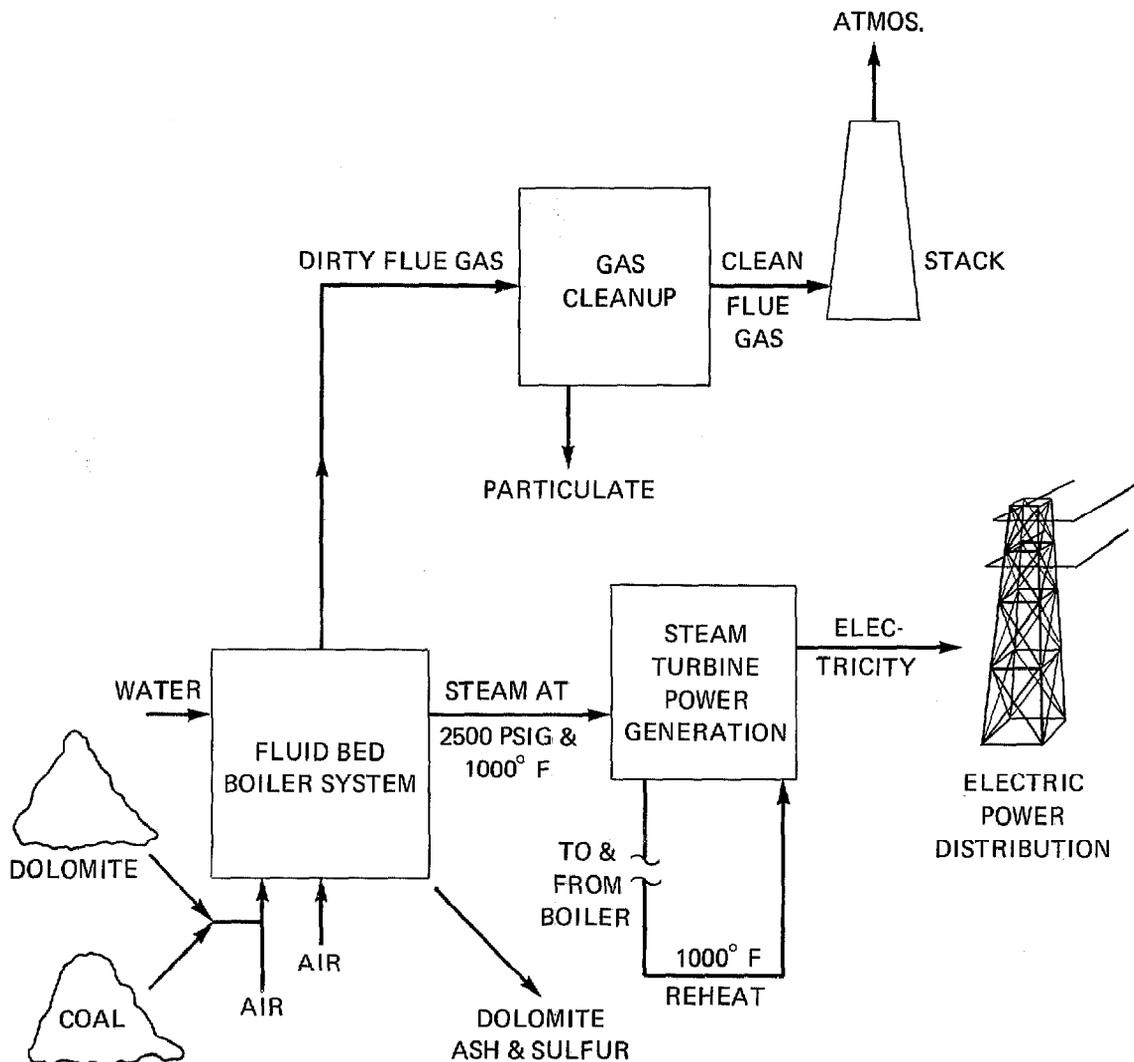
Federal efforts to control air pollution resulting from the burning of coal were initiated in 1963 with enactment of the Clean Air Act of 1963 (42 U.S.C. 1857). This act provided for grants to State and local agencies to assist in controlling air pollution and provided limited authority for Federal action to abate interstate pollution problems. The Air Quality Act of 1967 (42 U.S.C. 1857) and the Clean Air Amendments of 1970 (42 U.S.C. 1857) both amended the 1963 act and provided increased Federal authority to reduce air pollution.

With the creation of EPA in 1970, Federal research efforts to control air pollution resulting from burning coal were given greater emphasis. From fiscal year 1970 through fiscal year 1974, about \$65 million was expended on approximately 158 projects, primarily by EPA. The major emphasis in the Federal pollution abatement research effort has been on the removal of pollutants after the combustion of coal, although some research has also been conducted on chemical cleaning of coal to produce low-sulfur coal for the electric utility industry.

Summary of Advanced Fluidized Bed Processes

<u>Process name</u>	<u>Federal agency sponsor</u>	<u>Industry cosponsor</u>	<u>Contractor</u>	<u>Estimated funding to 6-30-74</u>			<u>Description</u>	<u>Process phase</u> <u>Estimated completion date</u>	<u>Estimated total cost</u> <u>(millions)</u>
				<u>Federal</u>	<u>Industry</u>	<u>Total</u>			
				<u>(millions)</u>					
Multicell Fluidized Bed Boiler	OCR	None	Pope, Evans, & Robbins	\$5.8	None	\$5.8	Pilot plant under construction expected to be operational in fiscal year 1975	1976	\$12.0
Fluidized Bed Combustion	EPA	Exxon Corp.	Same as cosponsor	1.2	.3	1.5	Pilot plant in operation	1977	5.4

FLUIDIZED BED COMBUSTION PROCESS



LEGEND:

PSIG – pounds per square inch gauge

ATMOS – atmosphere

DOLOMITE – calcium magnesium carbonate

Current Federal research efforts in this area have been primarily directed to the development of six advanced processes to remove pollutants resulting from the direct combustion of coal. The processes are similar in that each cleans gaseous emissions from coal burning electrical generation plants, but each process employs a different method of cleaning the gases.

As shown on the following page, one of the processes has been installed at private powerplants, although it is still being tested at a TVA powerplant; three of the processes are being demonstrated at several powerplants and are expected to be commercially available during the period 1975 to 1980, and the fifth and sixth processes are being tested at pilot plants.

Although EPA considers these six processes to be at an advanced stage, they are not considered as efficient or as economical as desired. EPA plans to continue its efforts to improve the efficiency and economy of these processes.

According to TVA studies, the cost to install a commercial process is expected to range from \$35 to \$43 million for a new large electric power generation plant, and from \$52 to \$68 million for an existing small plant. The TVA studies also indicate that the processes' cost could increase the average consumer's monthly electric utility bill by at least 10 percent, and possibly as much as 40 percent, depending on whether the equipment is installed in a new plant or is retrofitted in an existing plant.

An illustration of a process for the removal of pollutants after combustion is shown on page 57.

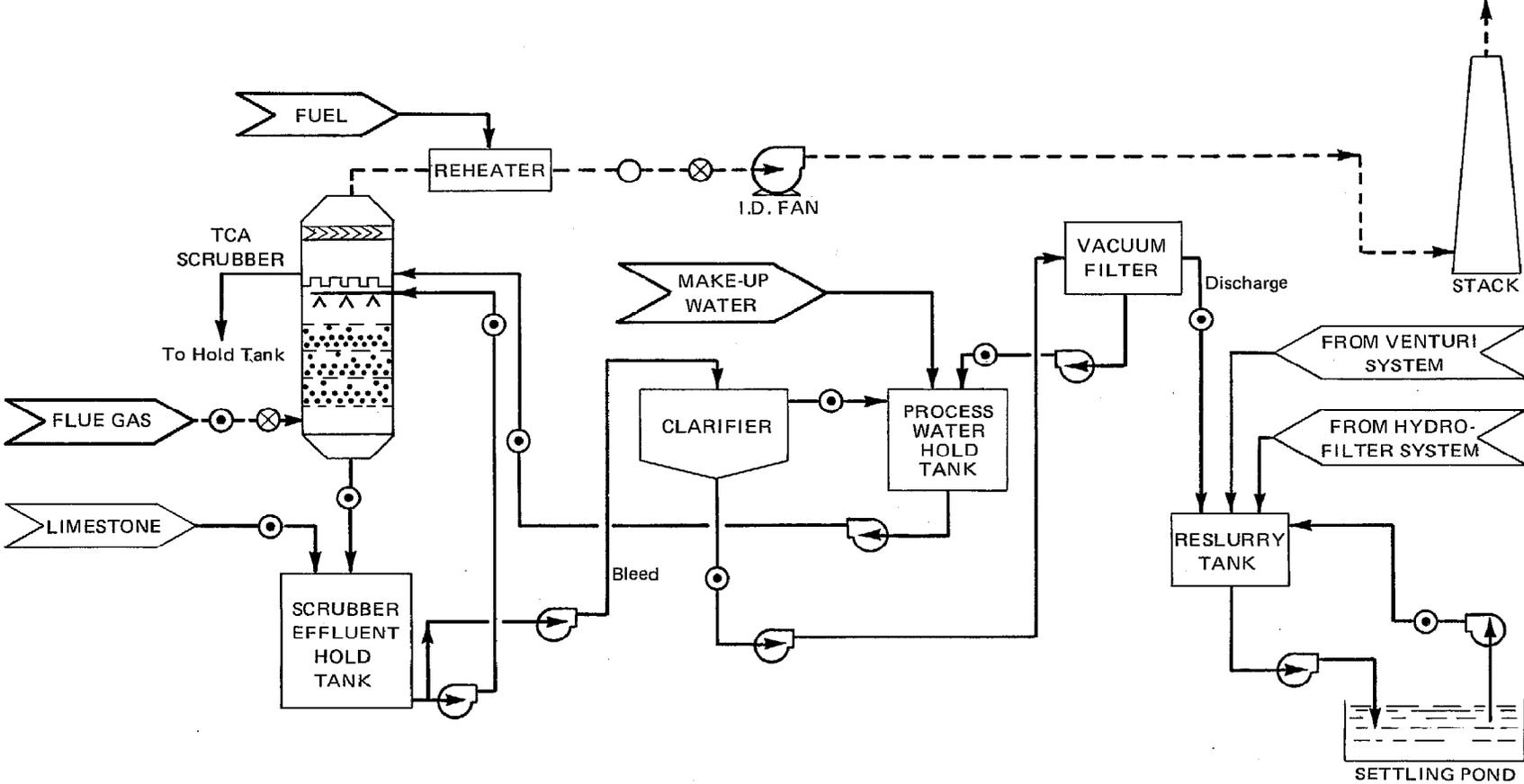
POTENTIAL PROBLEMS IN COMMERCIALIZATION
OF COAL CONVERSION PROCESSES AND AGENCY ACTIONS
TO RESOLVE THEM

Extensive research has been conducted on various coal conversion processes and with additional research and development on these processes there are prospects for commercialization in the late 1970s or early 1980s. There are potential problems, however, in specialized equipment, plant location, and capital requirements related to the

Summary of Advanced Pollution Abatement Processes

Process name	Federal agency sponsor	Industry cosponsor	Contractor	Estimated funding to 6-30-74		Description	Process phase	Estimated completion date	Estimated total cost (millions)
				Federal	Other Total				
Lime/Lime-stone Wet Scrubbing	EPA	None	Bechtel Corp. and TVA	\$13.3	None	\$13.3	Pilot process operational. Process has been installed in some private power plants	1976	\$19.6
Sodium Iron Scrubbing	EPA	Northern Indiana Public Service Corp.	Davy Power Gas and TRW Corp.	5.6	5.6	11.2	Process being demonstrated at a power plant	1977	13.0
Magnesium Oxide Scrubbing	EPA	Boston Edison and Chemico Inc.	Same as cosponsor	4.5	4.7	9.2	Process being demonstrated at power plants	1974	9.0
Catalytic Oxide Scrubbing	EPA	Illinois Power Company	Monsanto, Inc.	3.7	3.9	7.6	Process being demonstrated at a power plant	1975	8.0
Double Alkali Scrubbing	EPA	None	A.D. Little Company	.7	None	.7	Pilot plant process being tested	1975	.7
Ammonium Bisulfate Scrubbing	EPA	None	TVA	2.0	None	2.0	Pilot plant process under construction	1975	4.3

POLLUTION ABATEMENT STACK GAS SCRUBBING PROCESS



Source: Tennessee Valley Authority, represents the limestone scrubbing process.

LEGEND:

- Gas Composition
- ⊗ Particulate Composition & Loading
- Slurry or Solids Composition
- Gas Stream
- Liquor Stream
- I.D. Induced Draft
- TCA Turbulent Contact Absorber

eventual commercialization of these processes, which could delay the transition from the research phase to the commercial phase. The Project Independence report identified potential constraints on energy development. Federal agencies involved in energy matters are aware of these problems and have initiated or are planning actions to resolve them. These matters are discussed below.

Specialized equipment

Commercial coal conversion facilities will require large pieces of equipment capable of withstanding high temperatures and pressures. For example, the main piece of conversion equipment for one of the processes to convert coal to synthetic gas is expected to be about 250 feet high, have an inside diameter of about 22 feet, weigh 3,000 to 4,000 tons, and be capable of withstanding temperatures of 1,900 degrees fahrenheit and pressure of 1,200 pounds a square inch over long periods of time.

In our review of reports on energy-related matters as well as through discussions with individuals involved in coal research, we noted a concern over the ability and capacity of private industry to fabricate and erect the equipment that may be required for commercial coal processing plants.

For example, a 1973 Senate Committee on Interior and Insular Affairs report on "Energy Research and Development--Problems and Prospects" notes that shortages in manpower needed to design, construct, and operate conversion plants, and equipment and supplies for plants could occur. The report specifically states that plant design contractors and equipment manufacturers have questioned their industries' ability to meet anticipated equipment demands for coal conversion facilities as well as demand for similar types of equipment for the nuclear power industry.

A similar concern was expressed by a contractor official who is currently involved in a major coal conversion program sponsored by the Federal Government. This official stated that studies should be initiated to determine manpower requirements, availability of materials, and capability of contractor and suppliers to build and supply the needs of large coal conversion plants.

The Project Independence report notes that materials and equipment are fundamental to the development of energy resources and current energy development has been slowed by shortages of certain categories of equipment. It also noted that future energy development will place additional burdens on industrial capacity and raw materials availability.

The availability of steel products, such as heavy plate for pressure vessels, pumps, compressors, and piping and tubing, and the capability of the construction industry to build energy related facilities are two of the materials, equipment, and construction constraints set forth in the Project Independence report which have particular applicability to coal-related energy research. The report states that expansion of domestic steel-making capacity is important to increased energy development and the availability of financial capital appears to be the most serious constraint on capacity expansion. With respect to construction of energy facilities, the report states that this constraint is not severe but that the availability of financial capital, material, and labor shortages could affect the ability of the construction industry to expand to the needed capacity.

OCR also recognized that production of commercial equipment is a potential problem and has begun to study the problem. For example, OCR's contract evaluator for the high-Btu gas program is preparing commercial concept designs for each of the gasification processes. In carrying out the contract, the contractor will identify problems which must be resolved before equipment can be specified for manufacture and identify problems in field fabrication of large pieces of equipment. The OCR evaluator for the various processes to convert coal to synthetic oil will also carry out similar studies to identify equipment problems.

Conversion plantsite location

According to an OCR contractor developing a gas conversion process, the selection of sites for the location of coal conversion plants is important. The contractor pointed out that potential sites having adequate coal and water supplies to support the plants must be identified, the land must be obtained, contracts for coal and water supplies must be negotiated, various permits must be obtained from

appropriate authorities, and usually environmental impact studies must be conducted. These activities are time consuming and should be initiated as soon as possible to insure that sites for the location of conversion plants will be available when commercialization of the various conversion processes is achieved. For example, the environmental impact study for a major coal area in Wyoming took over a year to complete.

We discussed this matter with several Government and non-Government officials involved in coal conversion research activities. They agreed that the time required to resolve the economic and environmental issues of coal conversion plantsite selection could delay the realization of commercial application.

The selection of sites for energy facilities is also identified in the Project Independence report as a major environmental issue. The report points out that even with the best available control technology, these installations are significant sources of pollution. The location of such facilities in urban areas may make it impossible to reduce pollution to acceptable levels, whereas siting new facilities away from problem areas could degrade relatively clean environments, either directly or through resulting secondary development.

The availability of water, essential to almost every energy process, is also identified in the Project Independence report as a constraint on energy development and plantsite selection. Coal gasification and liquification plants are among those energy processes which require substantially high amounts of water. The report identified two regions--the Missouri and Upper Colorado River Basins--as having the most serious water problems. These regions have already experienced water supply problems and future development of large coal deposits in the regions could have serious environmental, social, and economic impacts.

OCR has awarded contracts to study and seek solutions to environmental problems involved in siting of coal-based industrial complexes. The objective of these contracts is to evaluate the best end uses of land, water, and other resources to achieve balanced industrial, economic, social,

and environmental development at potential locations in coal areas in the United States.

Among the contracts awarded by OCR is one under which work was initiated in June 1973. The intent of this effort is to provide a methodology for the environment-related factors that must be considered in constructing and operating coal conversion refineries and associated mining operations and for assessing environmental impacts. Potential land and water resource development will be defined along with opportunities and benefits for industrial, economic, and resource development. The contractor has compiled information for four regions of the country having coal reserves needed to support coal refineries capable of processing up to 75,000 tons of coal a day.

According to a 1974 OCR report, the contractor is evaluating the information obtained in order to define mining techniques and materials handling methods and equipment that could be used to conduct operations of this magnitude in each of the four regions. The report notes that as a part of this evaluation, assessments are being made of the environmental effects and the approach that might be used to mitigate such effects.

Another OCR contractor is studying the economic, social, and land-use activities and impacts that will result from development of a coal-mining processing complex to be located in a relatively undeveloped, somewhat isolated, and sparsely populated area. The area under study comprises the lignite reserves of the Fort Union deposit in Wyoming, Montana, and North and South Dakota which according to the Department of the Interior is one of the Nation's major regional energy storehouses.

Capital requirements

If current coal conversion research efforts prove successful and result in commercially viable conversion processes, entirely new coal conversion industries may be created. Current estimates of the cost to design and construct conversion plants, as high as \$785 million, indicate that these industries will have capital intensive characteristics. During our review, several energy industry representatives told us that because of uncertainty concerning the

role of coal in meeting future energy demand and because of competition from other energy sources, private industry may be unwilling or unable to provide sufficient funding for the coal conversion industry.

There are no precise estimates as to the number of conversion plants ultimately to be constructed, but the number could conceivably range into the hundreds. The capital requirement needs for these plants have been emphasized in many Government and non-Government reports and discussions concerning the energy situation and the use of coal in meeting our Nation's energy needs.

The Project Independence report points out that capital requirement needs for expanded energy development are potentially large enough to raise questions about the economy's capacity to provide funds. The report states that the financial situation of the electric utility industry, which would be a major user of coal research technology, is particularly critical and inadequate rates of return will not only reduce the internal funds available for expansion but also hamper the industry's ability to attract new investment.

OCR has contracted with several engineering and industrial firms for economic analyses of coal conversion processes which will define the capital and operating requirements for commercial plants. Also, the capital requirements problems associated with commercial coal-conversion processes are the subject of proposed legislation (S. 2956) introduced in the Congress in February 1974 which would establish a Federal Energy Production Corporation. This bill provides for the development of underutilized or unconventional energy sources, including synthetic fuels derived from coal, by means of grants, loan guarantees, price supports, guaranteed purchases, and low interest, short- or long-term loans. No action was taken on the bill.

CONCLUSIONS

Federal research efforts in the conversion of coal to synthetic gas and oil and the direct use of coal in electrical power generation are expected to produce commercially acceptable processes in the late 1970s or mid-1980s. Federal efforts in pollution abatement research have produced

several processes to remove pollutants resulting from the direct combustion of coal; however, these processes are not as efficient or as economical as desired.

The commercial feasibility of the coal conversion and utilization processes being developed will determine the extent to which the Nation's abundant coal resources will be utilized. However, we believe that the likelihood of commercially available conversion processes and improved pollution abatement processes by the late 1970s or mid-1980s will depend upon whether the Federal coal research agencies continue to receive adequate funding.

Although the commercialization of the coal conversion processes appears feasible by the mid-1980s, there are potential problems which may delay the transition from the research phase to the commercial plant phase. These problems include the development and fabrication of large-size specialized commercial plant equipment, the identification and selection of plant sites, and the availability of private investment capital to construct and operate the conversion plants.

Federal agencies involved in energy matters recognize the potential problems and have initiated studies to minimize or resolve them.

RECOMMENDATION

Because of the importance of the potential problem areas which could delay the transition from the research phase to the commercial production phase for various coal conversion processes, the Administrator of ERDA should give these potential problem areas early consideration in the planning for future coal research and development efforts. The Administrator should also consider the extent to which similar problem areas could impact on other energy sources.

MATTERS FOR CONSIDERATION BY THE CONGRESS

As part of its continuing deliberations on the Nation's energy situation, the Congress should consider the Federal incentives that might be needed to overcome the many problems which may delay the transition from the research phase to

the commercial production phase for various coal conversion processes. Such Federal incentives might be needed in the areas of (1) development of costly specialized equipment, (2) obtaining plantsite locations, and (3) capitalization of new conversion industries.

CHAPTER 4

COAL SUPPLY RESEARCH

From fiscal years 1970 through 1974, an estimated \$121 million was spent on coal supply research. About 90 percent--\$109 million--had been directed to mining health and safety research. Of the remainder only about 9 percent--\$11 million--had been directed to land reclamation and about 1 percent--\$1.5 million--to coal extraction technologies.

According to the Department, the demand for coal is expected to almost triple by 1985. Coal industry experts and other energy authorities have questioned the ability of the coal industry as presently constituted to meet the increased demand, because of problems in the areas of adequate mining technology, manpower, transportation, capital investment, and environmental considerations. An additional \$325 million in Federal funds for coal extraction and land reclamation research has been recommended by the Chairman of AEC for 5 years beginning with fiscal year 1975.

The status of Federal coal supply research, which has been carried out almost entirely by BOM, and potential problem areas in coal supply are discussed below.

STATUS OF COAL SUPPLY RESEARCH

Mining health and safety

From fiscal year 1970 through fiscal year 1974, BOM spent about \$109 million for mining health and safety research involving over 550 projects. About \$92 million was directed to safety research and about \$17 million to health research.

Safety research on equipment, methane gas control, and fire and explosion prevention was emphasized. Research was also done on post disaster and survival rescue and on developing and designing safer and more healthful mining systems. Health research was directed to the control of respirable dust, noise suppression, and improved detection and monitoring systems for toxic gases.

A BOM official told us that research had been directed to (1) improvements in dust suppression through the use of water and foam spraying, (2) the development of a portable dust collection system, (3) improvements in noise abatement, (4) an improved explosive proof bulkhead, and (5) improved post disaster survival and rescue procedures. He also said that BOM had directed particular attention to disseminating the results of its mining health and safety research and development efforts to private industry.

Although specific funding levels for this research during fiscal years 1975 through 1979 were not set forth in the recommendation of the Chairman of AEC, BOM officials told us that mining health and safety would continue to be emphasized through BOM's ongoing research program. They also told us that mining health and safety would be considered in its future research in improved coal extraction technology.

In its future research in mining health and safety, BOM plans to emphasize research directed to decreasing the number of injuries caused by mine roof falls. BOM also plans to research the human factors associated with mine industrial hazards.

Land reclamation

BOM and TVA spent \$11 million on land reclamation research from fiscal year 1970 through fiscal year 1974. BOM funded about 84 percent of this research, which was directed to demonstrating different methods of reclaiming lands disturbed by strip mining.

A BOM official told us that, although land reclamation research had been successful in demonstrating reclamation methods, additional research was necessary to develop integrated mining and reclamation methods.

BOM plans to undertake field demonstrations of reclamation technologies directed to (1) reducing land reclamation costs and (2) developing improved technology to speed up the land-healing process, resulting in reclaimed land which is in better condition than before mining.

For the fiscal years 1975 through 1979, the Chairman of AEC recommended \$325 million for research in coal extraction, which is to include research in land reclamation and environmental problems associated with coal mining.

Coal extraction

BOM will have expended only about \$1 million from fiscal year 1970 through fiscal year 1974 on research specifically directed to coal extraction. The project was directed to the development of a pneumatic (air blown) system for transporting coal from the face of the mine to a loading area and was completed in fiscal year 1972.

In addition to research specifically directed to coal extraction, BOM's coal mine health and safety research has some application to coal extraction technology. BOM officials believe benefits to coal extraction technology come about from improving the conditions of mining and although the objectives of health and safety research may be different from extraction technology research, the overall results benefit both research programs.

Of the \$325 million proposed by the Chairman of AEC for a mining technology research program, \$45 million would be provided in fiscal year 1975. Part of this proposed program would provide funds for the development and demonstration of new mining methods for both surface and underground mines aimed at increasing productivity with as complete extraction as possible in a manner that insures safety and environmental protection.

POTENTIAL PROBLEMS WHICH MAY DELAY INCREASED COAL PRODUCTION AND AGENCY ACTIONS TO RESOLVE THEM

Accelerated use of coal requires the resolution of many potential problems. Among them is the development of adequate mining capacity to meet the demand for coal. The key elements in providing additional capacity are the development of improved mining technology, attraction of adequate numbers of new workers into the mining industry, actions to insure the ready availability of transportation of coal or products derived from coal, and incentives to

attract investments in mines and other facilities essential to coal supply. Equally important, however, are the environmental regulations, either established or proposed, which impact on coal production.

With increased emphasis on energy self-sufficiency, and coal potentially a significant element in meeting this goal, these factors assume added importance. These factors were recognized as potential constraints on energy development in the report on Project Independence. Federal agencies involved in energy matters recognize these important potential problems and have initiated or are planning actions directed to their resolution. These matters are discussed below.

Improved mining technology

During this century, coal mining has been subjected to several major technological improvements which have advanced it from the "pick and shovel" era. These include the introduction and improvements of strip- or surface-mining techniques and the mechanization of underground mining systems.

Despite these major innovations, coal experts contend that mining technology, particularly for underground mining, has become stagnant over the past few years. According to the National Coal Association, the coal industry attributes this to the lack of coal-mining research. A major university conducted a workshop in 1973 on the issues of a national energy research and development program and reached a similar conclusion. This workshop concluded that underground coal-mining technology offers opportunities for further improvement but that research in this area has been restricted to improving health and safety underground. Similarly, a 1973 staff study for the Senate Committee on Interior and Insular Affairs found that coal-mining research was receiving almost no attention.

There seems to be no question that Government research on mining technology had received very little attention in the past. In analyzing Federal research expenditures during fiscal years 1970-74, we found that only about \$1.5 million of \$463 million was for projects involving mining technology.

BOM spent about \$1 million of this on one project. However, a substantial increase in mining research is projected for fiscal years 1975-79.

The surface coal-mining program will develop and demonstrate mining and reclamation systems and equipment that would permit surface mining in the western and Appalachian coal fields at minimum cost and environmental impact. Particular attention will be given to demonstration projects to assess the effects of the best present technology and to identify and resolve indicated deficiencies.

The underground coal-mining program plans to develop and conduct demonstrations of equipment systems for high-speed horizontal mine development, improved longwall mining, continuous materials-handling systems, improved roof control systems, commercial extraction of methane from virgin coal areas, and novel mining concepts. Technology for environmental protection associated with underground mining, including control of subsidence phenomena, control of chemical mine drainage effluents, and acceptable methods of waste disposal are expected to be demonstrated.

The mining technology research programs outlined above are aimed at increasing productivity. In our opinion, such programs are necessary if coal is to become a significant energy source.

Manpower

Even though the mining process has been mechanized to a large degree, manpower is still a major factor in mining coal. In 1973 there were about 155,000 men employed in bituminous and lignite coal mining and about 4,400 men in anthracite mining. This labor force mined about 600 million tons of coal. A spokesman for the Department stated that it could take as many as 300,000 new workers to meet the kind of production needed between now and 1985.

In December 1973 the National Coal Association reported to FEA that labor was one of the biggest factors delaying coal production and for the longer term was a major constraint to the expansion of coal production.

In a 1972 report the National Petroleum Council expressed similar views. It reported that attracting adequate numbers of new workers into mining remains a problem, especially because the increasingly sophisticated equipment used raises the required level of worker competence and training. According to the Council, a more serious shortage of certain trained supervisory and professional manpower may develop. They pointed out that only 20 colleges and universities offer undergraduate degrees in mining engineering or related areas and noted that these schools only graduated 132 mining engineers in 1970. According to the Department of the Interior data there were 280 undergraduate degrees awarded in mining engineering in the fall of 1973. Of the degrees awarded, about 10 percent went to foreign students.

Potential manpower shortages are also identified in the Project Independence report. The report points out that shortage of professionals and skilled craftsmen in selected occupations have hindered the development of some energy projects in recent years and that shortages could occur in some areas, particularly engineering. Although widespread shortages are not anticipated, the report states that regional imbalances in labor supply are expected. The report identifies the Northern Great Plains as an area which currently employs few workers in the energy sector but which would undergo rapid development in the future and incur shortages of miners and other workers as new surface mines are opened.

The Project Independence report states that although the responsibility for training to meet occupational requirements has traditionally been with industry, unions, and the educational sector, the Federal Government could take several actions to enhance work force mobility into needed occupations and locations when labor shortages may occur. These actions include

- taking the responsibility for providing a constant flow of information on occupations that will be needed and where they will be needed;

- working directly with unions, industry, and educational institutions to assist in planning for training programs, publicizing jobs, and encouraging mobility;
- encouraging the expansion of apprenticeship;
- establishing a clearinghouse for energy-related jobs;
- increasing or establishing scholarship assistance for selected occupations; and
- providing financial assistance for job relocation through tax credits or subsidies.

There seems to be no question that the ability to attract and train the coal industry's work force is a potential constraint and that some Federal action in this matter may be needed.

Transportation

In 1972, about 52 percent of bituminous coal shipments to U.S. destinations was moved by railroads; about 29 percent by water conveyances or inland waterways of the Great Lakes; about 12 percent by truck; and the balance was moved by tramway, conveyor, or private railroad. If coal production triples in the next 20 years, as some projections suggest, it appears that additional transportation facilities must be coordinated with the additional coal requirements. The future coal transportation complex is dependent upon many variables which bear on new mine development or increasing production capacity of existing mines.

For example, the bulk of the coal now mined for the conventional markets (electric power and steel) originates in the eastern United States. If eastern coal's environmental problems can be solved (i.e. elimination of the sulfur dioxide problem), then it is likely that these coal sources could provide most or all of the added coal for the conventional markets. Past transportation means would then serve as an indicator as to what additional transportation units might be required to move the increased coal

requirements. On the other hand, if coal desulfurization or sulfur dioxide stack gas clean up does not become readily available, then the low sulfur coals which are located in the Western States may become the source for the major conventional markets which are in the eastern and central parts of this country. To open up the western coal fields may require the construction of new rail lines and additional rail cars.

The supply of coal for complexes converting coal to gas or liquids will also influence the transportation aspects of coal. According to OCR officials it is expected that these complexes will be constructed on top of or adjacent to the vast surface coal deposits in the Western States. Thus the transportation problem is changed from moving the basic raw material (coal) to transporting the energy product derived from coal which may be in the form of oil, gas, and electricity. Transportation, in short, will be a major factor in expanding conventional coal markets as well as opening new coal markets.

The transportation of energy products and possible constraints on increased energy development was also discussed in the Project Independence report. With respect to coal, the report points out that, if coal production is to be increased, a large amount of growth will be needed in the coal transport system. New and improved rails and track beds will be needed, more rolling stock (hopper cars and locomotives) will be needed, and the railroad industry will need to be strengthened.

The report states that the availability of materials, manpower, and industry capacity could be a constraint on increased rolling stock and rail production, but that the most central problem is the poor financial position of the railroad industry. The railroad industry's financial position has deteriorated steadily in recent years and it may be difficult for the industry to finance needed capital expenditures. The report also states that growth in other methods of transporting coal or coal products, barge and pipeline, will also necessitate increased capital investment and that expansion could be constrained by the availability of materials, labor, and construction capacity. Planning, Federal regulatory, and other decisions will need to be made soon to insure adequate transportation capacity for

energy resources.

In May 1974, OCR awarded a 16-month contract to study the transportation of synthetic fuels from coal. In this study the contractor will evaluate the economics of delivering clean fuels and electricity by various transportation modes from the mine to the energy demand center.

Capital investment

Multibillion dollar capital investments in mines and other essential facilities are necessary for the coal industry to meet increasing demands. An official from a leading coal company cited a need for an increase of 1 billion tons of annual production by 1985, which would require a minimum \$10 billion capital investment, or \$10 for each added ton of capacity. A BOM official expressed similar views. He estimated investment for added capacity at about \$9 a ton for strip mines and at about \$15 a ton for underground mines, or a capital investment need of \$9 to \$15 billion for an added 1 billion tons of capacity.

Coal industry experts and other energy authorities have questioned whether the coal industry can raise the additional capital from private sources. For example, the National Coal Association views meeting the coal industry's finance requirements as a formidable task, especially for an industry with a current capitalization of \$4 billion. There is apparently very little incentive to attract private investment to develop new coal capacity. A July 1973 Department report notes that such factors as environmental constraints, increased oil imports, and growth and timing uncertainties of nuclear power generation have tended to discourage investments in coal mining that are needed to substantially increase capacity. This report adds that practically all new deep-mine capacity is presently being developed under long-term consumer contracts, and many large consumers are reluctant to negotiate contracts because of uncertainties in the competitive energy outlook.

The outlook of potential investors is a highly speculative issue. Nevertheless, it must be considered in planning for increased emphasis on coal as an energy source.

A legislative proposal (H.R. 12045) was introduced in the Congress in December 1973 which included substantive provisions for developing coal resources. This bill would have created the position of a coal administrator who would have been empowered to

- set goals for producing and converting coal into other forms of energy;
- insure a market for coal producers by giving them long-term contracts for purchasing their output;
- resell coal purchased under long-term contracts to utilities and other users;
- issue production orders giving coal producers first claim on materials and supplies needed to increase the production, transportation, and conversion of coal for energy purposes;
- provide financial assistance to railroads buying additional coal cars and improving road beds; and
- provide financial aid to utilities and others converting to the use of coal as an energy source.

The bill was assigned to the House Interstate and Foreign Commerce Committee but no action was taken on it.

As discussed previously, capital investment constraints and the means to overcome such constraints are also aspects of FEA's Project Independence report.

Environmental considerations

Concern over the environment is possibly one of the most important factors which has delayed the growth of coal as an important energy source in the past and which may limit future coal use unless conflicts between coal mining and coal use and the environmental issues can be resolved. The various phases of coal's economic cycle produce large amounts of environmental degradation. First, in order to recover coal, land has to be disturbed. Secondly, when most coal is burned, sulfur dioxide, identified as a major air pollutant by Federal Air Quality Standards, is released into the air.

The sulfur dioxide concern is the single most important factor influencing Federal coal use research. Most of the major research programs are conducted to find ways to burn coal in an environmentally acceptable manner. As discussed in chapter 3, this research is not expected to result in any commercially viable operations until the late 1970s or 1980s. Although research is expected to provide long-term solutions, the short-term problem is how to use greater quantities of coal to reduce the energy deficit. H.R. 11592, which was introduced in the Congress in November 1973 and referred to the House Interstate and Foreign Commerce Committee, would have temporarily relaxed or postponed mandatory implementation of the air standards to provide some immediate relief to the energy shortage. No action was taken on the bill.

Another major problem which could influence the coal supply is the environmental effect on mined land and surrounding areas. The environmental consequences which result when coal is mined are well known and have been given wide publicity in the press as well as in Government and private reports.

This increasing concern stems from the anticipated increased dependence on coal to alleviate the energy shortage. According to some reports, the bulk of the additional coal requirements may come from strip mining in the huge untapped western coal reserves. Mining of these reserves, according to some reports, poses serious reclamation problems especially because of arid conditions and thin and fragile topsoil. Problems associated with mining these reserves are (1) the availability of water for mining needs, (2) the water needs of proposed synthetic plants for generating coal into either gas or oil which are expected to be located near the coal mines, and (3) water to insure revegetation. These matters were discussed in chapter 3.

Federal land reclamation research, which amounted to about \$11 million during fiscal years 1970 through 1974, was directed to the demonstration of various methods to reclaim lands disturbed by mining. Future research will be directed to developing improved technology which will speed up the land healing process and reducing land reclamation costs.

We believe that such research is needed and should be accelerated to the extent possible, especially in view of the strip mining legislation pending before the Congress which could impact on the supply of coal.

The report on Project Independence devotes an entire chapter to an environmental assessment of the impact of increased energy development and points out that there is no simple way to evaluate the most environmentally protective of the options available. With respect to coal matters, the report points out that environmental considerations are considerable. These considerations include

- surface mining versus underground mining;
- acid mine damage, particularly in the Eastern United States;
- the use of proper reclamation techniques, particularly in areas of low rain fall levels;
- surface subsidence; and
- the disposal of liquid and solid waste materials.

There is no doubt that environmental considerations will have a significant impact on the increased production of coal and that such matters will need to be resolved on a national basis if coal is to have a noticeable impact on the solution of the Nation's energy problems.

CONCLUSIONS

If coal is to be used in large amounts as projected, there must be assurances that there will be a sound coal industry capable of mining and supplying the increased coal requirements. However, increasing coal production requires resolving many problems associated with its supply and use. Additional productive capacity will require improved mining technology, additional mining personnel, additional transportation equipment, and incentives to attract investments in mines.

Environmental regulations, both established and proposed, which impact on coal production could also impact on the industry's capability or willingness to develop additional coal production capacity.

Federal coal research agencies have recognized the issues associated with expanded coal production capacity and have taken action to resolve such issues. The recent report on Project Independence by FEA should assist in the resolution of these problem areas. Also, legislative measures dealing with these matters have been introduced in the Congress.

RECOMMENDATION

Because of the importance of the problems presently delaying the increase in our Nation's coal supply, particularly the need for improved mining technology, the Administrator of ERDA should give these problems early consideration in the planning for future coal research and development efforts.

MATTERS FOR CONSIDERATION BY THE CONGRESS

As part of its assessment of coal's potential as an energy source, the Congress should consider the need for action and funding to overcome the present problems delaying the increase in our Nation's coal supply. Such action and funding may be needed for (1) improving mine technology, (2) increasing manpower, (3) providing new transportation systems, (4) resolving environmental considerations, and (5) providing incentives to attract private investment.

Congress should consider the need for providing assurance to the coal industry that technological breakthroughs in other potential energy-producing sources, such as oil shale, solar energy, or nuclear energy, which could conceivably provide cheaper or more environmentally acceptable means of producing energy, would not result in a drastic diminuation of the role of coal in energy production, as had occurred after 1947 when oil and natural gas became highly competitive energy sources. Such assurance would seem to be needed to encourage investment in coal conversion plants, coal mining equipment, and coal transportation facilities as well as to interest sufficient personnel in acquiring the training and skills needed by an expanding coal industry.

CHAPTER 5

AGENCY COMMENTS AND OUR EVALUATION

DEPARTMENT OF THE INTERIOR

In its November 1, 1974, comments (see app. I) the Department of the Interior stated that it generally concurred with our proposal relating to determining whether procedures for exchanging research and development information with industry and foreign countries can be developed. The Department did state, however, that while the information exchange between the Federal Government, private industry, and other countries is not perfect, it is much better than is generally believed and there is excellent communication especially with respect to basic information in the technical community.

We agree that a considerable amount of research information is exchanged through current agencies' operating procedures particularly through person-to-person contact. We believe, however, that more formal procedures are needed to insure that Federal coal research agencies and other interested parties are aware of the entire spectrum of research efforts and the results being achieved by such research. We also believe that the dissemination of this information will assist in the direction and coordination of Federal coal research efforts.

The Department also provided us with comments which were primarily of a technical nature and which have been recognized where appropriate in the report.

FEA

FEA, in its October 1, 1974, comments (see app. II) stated that it would be pleased to cooperate in investigating better methods for exchanging industry and foreign developed coal research information. FEA stated that the unbalanced duplicating and sometimes competitive nature of past coal research activities suggest that a total energy approach rather than a specialized energy commodity approach is needed. FEA was pleased to note several references to the Project Independence attempt to consider the total energy

problem as an integrated whole. FEA was confident that the Project Independence report would be helpful to the Congress in its further consideration of our report suggestions.

FEA also stated that because much of our report is concerned with coal-oil-gas conversion research which has contributed the bulk of the coal research work to date, the report appears to imply that coal-oil-gas conversion will be the major coal contribution to Project Independence. FEA believes that in view of the problems still to be resolved for large-scale coal-oil-gas conversion technology, it appears that, at least for Project Independence, research directed to improving the efficiency of and control of pollution from the direct burning of coal may have greater payoff.

Coal-oil-gas conversion research has received the greatest funding emphasis in recent years and it appears that this emphasis will continue in future years. Therefore, such research activities are discussed at some length in this report. It was not our intention, however, to make any assumptions as to which specific research activities would provide the greatest benefit in achieving energy self-sufficiency.

EPA

In its October 25, 1974, comments (see app. III), EPA stated that our report was informative and appeared to be well thought out, but that a few exceptions were noted.

EPA did not believe that the level of its coal research activities had been properly reflected in the report because not enough attention had been given to its efforts in pressurized fluidized bed conversion process and in chemical coal cleaning. EPA stated that the report does not discuss its water pollution research efforts to develop technology for environmentally acceptable mining methods nor does it discuss National Academy of Engineers' and the Federal Power Commission's recent studies on fuel conversion and fluidized bed combustion.

Because of the many individual coal research projects done by Federal agencies, we concentrated our efforts on those research processes which have reached an advanced state and appear to have some prospect for commercialization.

EPA's major coal research emphasis has been directed to the abatement of pollutants resulting from the direct use of coal in electric power generation plants. These efforts are discussed in the report, as well as EPA's efforts in fluidized bed combustion processes. EPA's chemical coal cleaning efforts are not discussed at length in the report because EPA officials told us that such efforts have not reached the advanced stage, although the funding for such projects is included in pollution abatement funding statistics.

Concerning EPA's coal-related water pollution activities, the report notes that these efforts are not discussed because they were covered in our previous report on EPA's water pollution research activities. (See p. 16.) Also, the National Academy of Engineers' and the Federal Power Commission's studies were reviewed for applicability to our work, but they are not discussed in the report because of their technical nature and much of the information contained in the studies was obtained from Federal coal research agencies and included in our report.

EPA also urged that greater emphasis be placed on the need to consider the environmental impact of energy technologies simultaneously with technical and economic considerations. EPA also pointed out that it has the capability to assist in monitoring pollutants from energy technologies under development which could assist in providing information on clean energy technologies and the selection of appropriate sites for energy plants.

We agree that the environmental issues associated with the development of coal research technologies and increased coal production are important. The report points out that concern over the environment is possibly one of the most important factors which have delayed the growth of coal as an important energy source in the past and which may limit future coal usage unless conflicts between the mining and use of coal and environmental issues can be resolved in a rational manner. (See pp. 74-76.)

NSF AND TVA

NSF, in its October 22, 1974, comments (see app. IV), stated that in general the report conclusions appear to reflect accurate assessments, and salient topics are highlighted for congressional consideration. NSF also provided comments concerning the coordination of coal research projects between Federal coal research agencies and suggested changes in the description of its coal research activities.

TVA's September 27, 1974, comments (see app. V) were primarily technical and have been recognized where appropriate in the report.

CHAPTER 6

SCOPE OF REVIEW

We directed our review toward determining the status of the Federal coal research programs and the problems which need to be resolved so that these programs may help solve the Nation's energy problems.

We made our review at the headquarters of OCR and BOM in Washington, D.C.; at NSF's and FEA's headquarters in Washington, D.C.; at EPA's Control Systems Division in Durham, North Carolina; and at TVA's Power Research headquarters in Chattanooga, Tennessee. We also visited Federal research laboratories and contractor facilities involved in or responsible for evaluating coal research projects and attended coal seminars sponsored by Federal and private coal organizations.

We reviewed legislation; Federal agencies' and contractors' records, reports, and documents relating to coal research; interviewed Federal and private industry officials and other interested parties in the field of coal research; and examined studies and research projects dealing with coal.

We obtained information on coal research from the National Coal Association, AGA, the American Petroleum Institute, and the United Mine Workers Union. We also obtained and reviewed information from the National Technical Information Service, the Smithsonian Scientific Information Exchange, the Library of Congress, and AEC.



United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

NOV 1 1974

Mr. Henry Eschwege
Director, Resources and
Economic Development Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

We have reviewed the draft of your report "Federal Coal Research - Status and Problems to be Resolved" and feel that GAO is to be commended for the wealth of information contained in the report.

We generally concur with your recommendation relative to determining whether procedures for exchanging research and development information with industry and foreign countries can be developed.

While the information flow between the activities of the Federal government, private industry, and other countries is not perfect, it is much better than is generally believed; and there is excellent general communication, especially with respect to basic information in the technical community. We believe that we should explore whether procedures for further improving information exchange can be implemented.

[See GAO note.]

Attached are specific comments keyed by page number in the draft. Some of the comments correct errors of fact; others provide additional information which you may wish to incorporate in the final draft.

Sincerely,

Allan L. Reynolds

Director of Audit and Investigation

GAO note: The deleted comment relates to a matter which was discussed in the draft report but omitted from this final report. Also, the attachment contained comments which were primarily of a technical nature and is not included here. This final report has been revised to take the comments into consideration, where appropriate.

Save Energy and You Serve America!

Attachment



FEDERAL ENERGY ADMINISTRATION

WASHINGTON, D.C. 20461

OCT 1 1974

OFFICE OF THE ADMINISTRATOR

Mr. Elmer B. Staats
Comptroller General of the
United States
General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Staats:

I have reviewed the comprehensive and informative review of coal research which you forwarded for comment. Your draft report contains two administrative suggestions relating to coal research.

1. That the Secretary of the Interior and the Administrator of the Federal Energy Administration determine whether some procedures can be devised for collecting and exchanging coal research and development information from industry and foreign projects.

[See GAO note, p. 85.]

The report also suggests that Congress consider action to:

1. Help translate research ideas into full scale coal conversion plants.
2. Help increase the supply of coal.
3. Assure that there is a floor price support under coal to guarantee investments in coal utilization, production and transportation facilities.

The Federal Energy Administration would be happy to cooperate with the Secretary of the Interior to investigate better methods for exchanging industry and foreign developed coal research information. It is possible that this task should eventually be assumed by ERDA if it comes into existence.

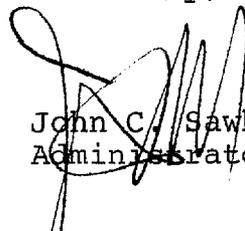
[See GAO note.]

Much of the draft report is concerned with coal-oil-gas conversion research work which has contributed the bulk of coal research work to date. The report appears to make the implicit assumption that coal-oil-gas conversion will be the major coal contribution to Project Independence. In view of the formidable problems still to be solved for large scale coal-oil-gas conversion technology, it appears that, at least for Project Independence, research to improve the efficiency of and control the pollution from direct burning coal may have a greater payoff.

The report notes that one of the coal research problems has been agency mission oriented research without clear overall direction and coordination. The Federal Energy Administration is pleased to note several references to our attempt to consider the total energy problem as an integrated whole. The unbalanced, duplicating and sometimes competitive nature of past coal research activities suggest that a total energy approach rather than a specialized energy commodity (oil, coal, etc.) approach is needed.

We are confident that the Federal Energy Administration Project Independence Blueprint to be delivered to the President by November 1, 1974, will be helpful to the Congress in its further consideration of your Coal Research Report suggestions.

Sincerely,



John C. Sawhill
Administrator

GAO note: The deleted comment relates to a matter which was discussed in the draft report but omitted from this final report.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 25 1974

Mr. Henry Eschwege
Director, Resources and Economic
Development Division
U. S. General Accounting Office
Washington, DC 20548

Dear Mr. Eschwege:

Thank you for the opportunity to comment on the draft of your proposed Report to Congress on "Federal Coal Research - Status and Problems to be Resolved." Basically the report is informative and appears to be well thought out. However, a few exceptions are noted below.

While the U. S. Environmental Protection Agency (EPA) recognizes the substantial coal related research carried out by the Office of Coal Research and the Bureau of Mines, it is felt that the report does not properly reflect the level of coal related research carried out by EPA. More attention should be given to EPA's work on pressurized fluidized bed schemes which have now become the most economically and technically favorable approach. For FY 1970-74, EPA's expenditures reached \$6.4 million. There is also no reference to the extensive work being done by EPA in the area of chemical coal cleaning. This process, frequently referred to as the Myers Process or the TRW Process, is a major effort to develop an alternative method for providing low-sulfur coal to the utility industry.

We also feel the description of the Tennessee Valley Authority's involvement in coal related research is somewhat misleading. Most of their research program has been done through interagency transfer from EPA, and with the exception of strip mine reclamation their energy related research activities lie in the future.

The draft states that EPA has carried out coal related research activities to prevent and control air and water pollution. This is an accurate statement. However, reviewers appear to have considered only that part of EPA's coal research activities located in the Control Systems Laboratory of the National Environmental Research Center (NERC) at Research Triangle Park, North Carolina, which has

responsibility for air pollution oriented activities. They have omitted the activities at NERC-Cincinnati which are water pollution oriented and in part pertain to technology development for environmentally acceptable mining methods.

You will recall that GAO spent considerable time reviewing the activities of the Mining Pollution Control Branch in our Industrial Waste Treatment Laboratory at NERC-Cincinnati during the development of your report on "Research and Demonstration Programs to Achieve Water Quality Goals: What the Federal Government Needs to Do." We feel much of that information could be incorporated in this report to present a more realistic picture of EPA's total effort in the area of coal related research. For example, the total EPA expenditure of \$60.5 million shown on page 40 would be augmented by \$10-12 million if you included the water pollution control activities in the coal programs at NERC-Cincinnati during FY 1970-74.

With reference to the selection of plant sites, it would be appropriate to mention EPA's current overhead monitoring capability which could be expanded with additional resources to provide the nucleus for objective site surveys. This could reduce industry's long term difficulty with environmental impact. EPA's expanded role in monitoring pollutants from technologies under development (demonstration plants, etc.) will also provide early information on potentially clean energy technologies.

The report fails to include any references to the recently completed study by the National Academy of Engineers on Fuel Conversion and Fluidized Bed Combustion, or work which was completed approximately a year ago by the Federal Power Commission. Reference should also be made to the Federally sponsored fuel cell program. This program, although relatively small, is of considerable importance to the overall energy program. Much of the work to date has been and is being done in the private sector. However, substantial funding and expertise reside in the Federal system and should be included to complete the picture of the total Federal energy R&D program.

In the report, reference to the environmental problems associated with the overall Federal energy program is weak. Little constructive reference is made to the need for a research and development program to deal in a positive way with the environmental problems. For example, a point that should be strongly made is that many of the processes including shale oil conversion, coal extraction, fuel pre-treatment, combustion, and combustion product disposition create serious environmental problems. It would be exceedingly unfortunate to opt

for the commercialization of a process that is among the poorer process options from an environmental impact standpoint if alternatives and trade-offs are available. To this end, it is important that the assessment of environmental impacts of specific coal conversion processes proceeds jointly with the development of the basic technology. It is not practical to expect that problems created by ignoring environmental impact during the design of a process can be easily or cheaply resolved once the technology is pressed into commercialization. The need for incorporating environmental consideration in the technology development phase should be strongly stressed.

On October 11, 1974, the President signed into law the Energy Reorganization Act of 1974 which established the Energy Research and Development Administration (ERDA). Under the Act, several coal research and development functions are transferred to ERDA. While the Department of Interior's Office of Coal Research and several programs of the Bureau of Mines were transferred, the coal-related functions of the Environmental Protection Agency were not. Since our coal-related research and development programs are primarily in support of our regulatory duties, the House and Senate conferees agreed that the EPA should continue to exercise these coal-related functions. To do otherwise, the Congress reasoned, might severely restrict the ability of the EPA to achieve its statutory mandates as they relate to the control of pollution from coal. We suggest that this decision be reflected in the report.

[See GAO note, p. 89.]

[See GAO note.]

In conclusion, we urge GAO to emphasize in the report that environmental impact of energy technologies must be considered simultaneously with technical and economic considerations if this Nation is to overcome the costly "retrofit syndrome."

Thank you again for the opportunity to make the above comments.

Sincerely yours,



Alvin L. Alm
 Assistant Administrator
 for Planning and Management

Enclosure [See GAO note.]

GAO note: ~~The deleted comments and the enclosure were primarily of a technical nature.~~ The report has been revised to take the comments into consideration, where appropriate.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550OFFICE OF THE
DIRECTOR

October 22, 1974

Mr. Gregory J. Ahart
Director, Manpower and Welfare Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Ahart:

This is in response to your letter of August 30, 1974, requesting comments on the General Accounting Office draft report entitled "Federal Coal Research - Status and Problems to be Resolved."

In general, the conclusions reached by the General Accounting Office appear to us to reflect accurate assessments, and salient topics are highlighted for congressional consideration. Our comments and suggestions concerning specific parts of the draft report are presented in the following paragraphs.

The statements made concerning the absence of central direction of the overall Federal Coal Research Program (pages 3 and 23) convey the impression that there has been no coordination between the agencies involved in coal research. For example, the statement ". . . each agency establishing its own objectives, priorities, and goals" provides an inaccurate assessment of the situation. Representatives of the Advanced Energy Research and Technology Division (AERT) of NSF's Research Applications Directorate hold regular coordination meetings with representatives of the Office of Coal Research (OCR) in the Department of the Interior during which programs and individual research proposals are discussed as to program fit and technical merit. In addition, all proposals relating to energy resources research are forwarded to the Office of Coal Research for formal review and comment. Similarly, OCR research proposals are forwarded to NSF for review and comment. Additionally, NSF resource proposals are submitted to the Atomic Energy Commission, U. S. Bureau of Mines (BOM), and/or Electric Power Research Institute for review. Further, OCR or BOM personnel are members of technical review panels and participate in formal grant presentations when possible.

[See GAO note, p. 91.]

[See GAO note.]

We appreciate the opportunity to comment on the GAO draft report and trust that the foregoing comments will be helpful.

Sincerely yours,

A handwritten signature in cursive script, appearing to read "H. Guyford Stever".

H. Guyford Stever
Director

GAO note: The deleted comments were primarily of a technical nature. The report has been revised to take the comments into consideration, where appropriate.

TENNESSEE VALLEY AUTHORITY
KNOXVILLE, TENNESSEE
37902

TVA
40TH
ANNIVERSARY
OF PEOPLE IN
PARTNERSHIP

September 27, 1974



Mr. Henry Eschwege, Director
Resources and Economic Development Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

In reply to your letter of August 30, 1974, enclosed are our comments on your proposed report to the Congress on "Federal Coal Research--Status and Problems to be Resolved."

We agree that a meeting of our respective staff people would be desirable before the report is issued. Mr. Carl Podeweltz of TVA's Power Research Staff will coordinate TVA's participation. Mr. Podeweltz's telephone number in Chattanooga is (615) 755-2884.

Sincerely yours,

A handwritten signature in cursive script that reads "Lynn Seeber".

Lynn Seeber
General Manager

Enclosure [See GAO note.]

GAO note: The enclosed TVA comments were primarily of a technical nature and are not included here. The report was revised to take the comments into consideration, where appropriate.

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John C. Sawhill	May 1974	Dec. 1974
William E. Simon	Dec. 1973	May 1974

- a/ Deputy Assistant Secretary in charge.
- b/ The Office of Research and Development was established in May 1973.
- c/ Title changed from Assistant Administrator for Research and Monitoring, effective May 29, 1973.
- d/ Title changed from Deputy Assistant Administrator for Monitoring, effective May 29, 1973.
- e/ Served the first two months of office as an acting Director.
- f/ Federal Energy Office from December 1973 to May 1974.

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