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*REPORT TO THE SENATE COMMITTEE  
ON PUBLIC WORKS*

093745



*BY THE COMPTROLLER GENERAL  
OF THE UNITED STATES*

Status And Obstacles To  
Commercialization Of Coal  
Liquefaction And Gasification

Energy Research and Development Administration

Processes which produce synthetic oil and gas from coal are commercially available but are not competitive with conventional oil and gas. Apparently no serious consideration is being given to building a commercial coal liquefaction plant in the United States.

A number of companies have announced projects to build high British thermal unit gasification plants. The most advanced of these projects have encountered problems which have precluded the scheduled advancement of the projects.

The Energy Research and Development Administration is researching coal liquefaction and gasification processes, which proponents hope will reduce the cost of synthetic oil and gas. These processes require considerable time before they can produce synthetic fuels on a commercial scale.

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

B-151071

The Honorable Jennings Randolph  
Chairman, Committee on Public Works  
United States Senate

Dear Mr. Chairman:

On August 11, 1975, you requested that we review certain aspects of coal liquefaction and gasification technology.

Responding to your request, this report discusses

- the Energy Research and Development Administration's program for developing new coal conversion processes;
- the status of major Energy Research and Development Administration-sponsored research efforts in coal liquefaction and gasification;
- the status of existing coal liquefaction and gasification technology; and
- the economic and other constraints to developing and commercializing coal liquefaction and gasification processes.

The matters presented were discussed with Energy Research and Development Administration officials and their comments were considered during report preparation.

We will be in touch with your office in the near future to arrange for release of the report so that copies can be provided to other congressional committees and interested Members of Congress.

Sincerely yours,

*James B. Peets*  
Comptroller General  
of the United States

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## ABBREVIATIONS

Btu	British thermal unit
ERDA	Energy Research and Development Administration
FPC	Federal Power Commission
GAO	General Accounting Office

COMPTROLLER GENERAL'S  
REPORT TO THE HONORABLE  
JENNINGS RANDOLPH, CHAIRMAN  
COMMITTEE ON PUBLIC WORKS  
UNITED STATES SENATE

STATUS AND OBSTACLES TO  
COMMERCIALIZATION OF COAL  
LIQUEFACTION AND GASIFI-  
CATION  
Energy Research and  
Development Administration

D I G E S T

Domestic supplies of gas and oil have not kept pace with increasing demand. Natural gas production has been declining and this decline is likely to continue. Domestic oil production peaked before 1970 and has been declining ever since.

Coal constitutes about 85 percent of our Nation's proven fossil fuel reserves but supplies less than 20 percent of our energy needs. Processes now exist and are being developed that can convert coal into synthetic oil (liquefaction) and into synthetic gas (gasification). Processes which were or are now in commercial use are referred to as first generation; processes which are being developed and have not yet been used commercially are referred to as second generation. (See pp. 9, 13, and 39.)

The Energy Research and Development Administration is funding development work on a number of new or second-generation liquefaction and gasification processes. When developed successfully, the Energy Research and Development Administration expects these processes would reduce the cost of synthetic oil and gas by 15 percent or more. The Energy Research and Development Administration spent about \$205 million in fiscal year 1975 on this development work and is authorized to spend about \$250 million in fiscal year 1976 and the 3-month transitional quarter. (See p. 7.)

A commercial liquefaction or gasification plant may process about 25,000 tons of coal a day. The Energy Research and Development Administration's efforts on coal liquefaction and gasification have not yet progressed to the point where a plant has been built that can process more than 100 tons of coal a day. Construction of a 2,600-ton-a-day liquefaction demonstration plant, funded by the Energy Research and Development Administration and private industry, is expected to begin in 1977, and the 3-1/2 year operation of the plant is expected to begin about 1979.

Although categorized as a liquefaction demonstration, this plant is expected to produce 3,900 barrels a day of liquid product, and the equivalent of 3,900 barrels of oil a day of pipeline quality gas. Once successful demonstration-scale operation is achieved, the Energy Research and Development Administration expects little technical risk in scaling-up to commercial size. (See pp. 12 and 13.)

These second-generation processes still require considerable development and time before they will be available for commercial use. In fact, the Energy Research and Development Administration's production goal for second-generation coal liquefaction processes by 1985 has already slipped considerably from its July 1975 projection. Assuming the current pace of development continues, the revised goals would be difficult to achieve. In fact, it appears highly unlikely that any commercial-sized coal liquefaction plant will be operating in the United States by 1985. (See pp. 20 and 21.)

Some coal liquefaction and gasification plants have been operating commercially for years but primarily in foreign countries. A principal obstacle to operating such plants commercially in the United States has been the availability of less expensive natural oil and gas. (See p. 39.)

There does not appear to be any serious consideration being given to building a commercial-scale coal liquefaction plant in the United States using an existing (first-generation) coal conversion process. In the gasification area, at least 16 projects have been announced but only 3 have progressed to the point of applying for the required Federal Power Commission approval. (See p. 22.)

Commission decisions have established precedents that could play a major role for the future of a synthetic gas industry. Also, State public utility commissions might not allow the high cost of synthetic gas to be passed on to customers in their States unless the Federal Government guarantees that the price will not exceed a specified level. The Synfuels Interagency Task Force recommended that the Government provide loan guarantees for initial high-British thermal unit coal gasification projects. In our opinion, the views expressed by regulatory agencies indicate that regulatory changes or Federal subsidies might be

needed in addition to loan guarantees. (See pp. 25, 30, and 37.)

Economic constraints to building commercial coal gasification and liquefaction plants include such things as large capital requirements, the questionable ability to obtain private sector financing, cost escalation, and price competition from other fuel sources. These have presented serious problems to presently planned projects and will probably be equally serious for future projects. Other considerations, such as environmental uncertainties and the necessity for large amounts of water to process the coal, must receive further study. The Energy Research and Development Administration and other Federal agencies plan to assess these factors during the first phase of the proposed synthetic fuels commercialization program. (See pp. 2, 26, and 32.)

Estimates for energy contributions from coal liquefaction and gasification have been dramatically reduced during the past year.

In June 1975, the Energy Research and Development Administration's "National Plan for Energy Research, Development, and Demonstration" projected a contribution of 2-1/2 million barrels of oil a day by 1985 from first-generation coal liquefaction processes and the equivalent of 1/2 to 1-1/2 million barrels a day from first-generation gasification processes.

These estimates are being revised and a draft document no longer projects a production goal from liquefaction processes by 1985 and projects the equivalent of 250,000 to 500,000 barrels of oil a day from coal gasification processes. GAO believes that even the revised gasification estimate could be difficult to achieve. (See p. 36.)

## CHAPTER 1

### INTRODUCTION

Three-fourths of the energy used in the United States comes from oil and gas, supplies which are limited and projected to decline rapidly. As domestic supplies of these two fossil fuels dwindle, imports of petroleum products and natural gas continue to climb. In 1975, 37 percent of our petroleum requirements were imported at a cost of about \$27 billion. Imports of natural gas amounted to less than 5 percent of our consumption requirements during 1975.

The Federal Energy Administration predicts that, if past trends continue, by 1985 we will import up to 12.7 million barrels of oil a day, or more than half our oil needs. The gas situation is also critical as gas companies have already begun curtailing supplies to low priority customers, and in some areas such curtailments appear to be in the offing for high priority customers. The Energy Research and Development Administration (ERDA) projects that during the 15 years preceding the turn of the century, the Nation's most critical energy problem is expected to be the liquid fuels gap.

At the same time, the Nation's coal supply is very large. Total domestic coal resources are estimated at 3.97 trillion tons. Recoverable coal reserves are much smaller than estimated resources because only a fraction of the total resources are considered mineable with present technology and under present economic conditions. Recoverable coal reserves are estimated at about 219 billion tons, which at the present rate of consumption would last more than 300 years.

The United States has four types of coal--each with a different heat content--anthracite, bituminous, subbituminous, and lignite. Of total identified coal resources, about 43 percent is bituminous, about 55 percent is subbituminous and lignite, and less than 2 percent is anthracite. Almost all lignite and subbituminous coal is found in States west of the Mississippi River and in Alaska. Most bituminous coal is found in the central and eastern United States. Anthracite coal is found primarily in Pennsylvania. Generally, the western coal does not have as much energy content for each ton as eastern coal but the sulphur content of western coal is generally lower, making it more acceptable environmentally.

The United States relies most on its plentiful domestic energy resources and least on its most abundant ones. Coal constitutes about 85 percent of the Nation's reserves of all fossil fuels but supplies less than 20 percent of our energy

needs. According to ERDA, the direct burning of coal must play an important role in our energy future. However, direct burning often cannot substitute for the Nation's liquid and gaseous energy needs. Processes now exist and are being developed that can convert coal into oil and gas and thereby help reduce our imports and shortages of these fuels. These processes are called coal liquefaction and coal gasification.

There are basically two groups of liquefaction and gasification processes. One group could be referred to as first generation, this includes those processes that were or are now in commercial use. Only a few very small plants that use these processes exist in the United States today, primarily because natural oil and gas are cheaper. The other group could be referred to as second generation, this includes those processes which are being developed and have not yet been used commercially. ERDA expects that these processes, once successfully developed, would reduce the cost of synthetic oil and gas by 15 percent or more.

ERDA's June 1975 "National Plan for Energy Research, Development, and Demonstration" projected that first-generation liquefaction technology could be producing at least 2-1/2 million barrels of oil a day by 1985, while first-generation gasification technology could be producing the equivalent of between 1/2 and 1-1/2 million barrels of oil a day by 1985. ERDA is now revising these estimates, and a draft document no longer projects a 1985 production goal from coal liquefaction processes and projects the equivalent of between 250,000 and 500,000 barrels of oil a day from coal gasification processes.

#### IMPETUS FOR U.S. EFFORTS TO PRODUCE SYNTHETIC FUELS

In his 1975 State of the Union Message, the President called for accelerated development of the Nation's energy technology and resources and proposed a set of energy supply and conservation measures to reduce the United States dependence on foreign oil by 1985. As part of these measures, he proposed that the Government provide financial and other incentives to stimulate investment in a number of commercial-scale synthetic fuel plants. In addition, he set a goal to produce the equivalent in synthetic fuels of 1 million barrels of oil a day by 1985.

In response to the President's goal, a synfuels inter-agency task force was established in February 1975, under the aegis of the Energy Resources Council, to study and make recommendations on Federal policy and programs for synthetic



fuels. In November 1975, the task force issued its report "Recommendations for a Synthetic Fuels Commercialization Program." The report recommended a two-phased program to achieve the President's goal of producing the equivalent of 1 million barrels of oil a day from synthetic fuels by 1985.

The first phase would be aimed at developing information on, and demonstrating the technical, economic, and environmental feasibility of commercial-scale plants using available (first-generation) technologies. ERDA believes that this information would contribute to the commercialization of a large number of coal conversion plants.

The first phase calls for constructing and operating about 12 to 15 commercial-sized plants using different energy resources and synthetic fuels technologies. It is anticipated that the equivalent of about 350,000 barrels of oil a day would be produced in the first phase. Of the 350,000, the equivalent of about 220,000 barrels a day would be synthetic gas from coal, and the remainder would be almost entirely from oil shale. No production is expected during this phase from coal liquefaction processes.

The second phase of the program, if undertaken, would be aimed at the production of the remaining 650,000 oil equivalent barrels a day needed to meet the President's goal. A decision regarding the pace, nature, and scope of the second phase will not be made until the 1979-80 time frame when more information becomes available on

- the environmental and other impacts associated with synthetic fuels processes,
- results of research and development aimed at improving synthetic fuel processes,
- the world energy situation, and
- the industries' response to the first phase.

#### COMMERCIALIZING FIRST-GENERATION TECHNOLOGY

The President designated ERDA to carry out the first phase of the synthetic fuels program. To carry out this responsibility, the task force recommended that ERDA establish a synthetic fuels program under a separate assistant administrator so that the program could be carried out in a commercial environment rather than in a research and development environment. The task force also recommended that, although ERDA has most of the basic statutory authority necessary to

implement the program under the Federal Nonnuclear Energy Research and Development Act of 1974 (42 U.S.C. 5901) the act should be amended to authorize ERDA to make loan guarantees under the program. ERDA is now supporting legislation which would give it this additional authority.

On January 30, 1976, ERDA established the Office of Commercialization. One of the purposes of this office is analyzing and planning the synthetic fuels commercialization program.

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We issued a report to the House Subcommittee on Energy Research, Development, and Demonstration (Fossil Fuel), Committee on Science and Technology (RED-76-82) on March 19, 1976. That report evaluated a proposal which would have authorized a loan guarantee program for commercial synthetic fuel demonstration facilities and discussed the Administration's efforts for implementing such a program.

## CHAPTER 2

### ERDA'S COAL CONVERSION PROGRAM

Before the Energy Research and Development Administration (ERDA) was established on January 19, 1975, coal research activities were carried out by the Department of the Interior, <sup>1/</sup> the Environmental Protection Agency, the Tennessee Valley Authority, and the National Science Foundation. Until then, there was no focal point for Federal coal research efforts. Coal research evolved over a period of years in response to the specific interests of these various agencies, with each agency pursuing its own research objectives and priorities.

ERDA was authorized to bring together and direct Federal activities relating to research and development of the various sources of energy and to perform various other functions. ERDA's responsibilities include:

- Exercising central responsibility for policy planning, coordination, support, and management of all energy research and development programs.
- Encouraging and conducting research and development, including demonstration of commercial feasibility and practical applications related to the development and use of various energy sources.
- Participating in and supporting cooperative research and development projects which may involve contributions to the performance of the work by public or private persons or agencies of financial or other resources.

ERDA's authority to provide Federal assistance and participation for developing new technologies includes (1) joint Federal-industry experimental, demonstration, or commercial corporations, (2) contractual arrangements with non-Federal

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<sup>1/</sup> The Office of Coal Research, Department of the Interior, was the principal Government research entity involved in converting coal to synthetic fuel. All the functions and personnel of this Office were transferred to ERDA. An earlier GAO report, "Federal Coal Research--Status and Problems to Be Resolved" (RED-75-322), dated February 18, 1975, addressed coal research, including coal supply research, before the establishment of ERDA.

participants, (3) contracts for construction and operation of federally owned facilities, (4) Federal purchases or guaranteed prices of the products of demonstration plants (subject to congressional authorization of each price support program), (5) Federal loans to non-Federal entities conducting demonstrations of new technologies, and (6) patent waiver authority.

#### FUNDING AND STRATEGY

ERDA's coal conversion research and development program is aimed at developing and demonstrating second-generation technologies to convert domestic coal into liquid and gaseous fuels. ERDA's strategy envisions developing various second-generation processes progressively scaled-up to a point where private industry will begin sharing development costs and eventually take the steps necessary to use selected processes on a commercial scale. The current program is exploring the following areas: (1) liquefaction conversion processes which will provide substitute fuels for liquid boilers, transportation, chemical feedstocks and other uses, (2) gasification processes which will produce gas of high British thermal unit  $\frac{1}{1}$  (Btu) value (about 950 to 1,000 Btu's a cubic foot) as a substitute for natural or pipeline gas, and (3) gasification processes which will produce gas of low- or medium-Btu quality (about 100 to 500 Btu's a cubic foot) as a substitute fuel for conventional boilers, other industrial applications, and chemical feedstocks.

The following table summarizes the funding levels of ERDA's liquefaction and gasification program.

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1/ The amount of energy necessary to raise the temperature of 1 pound of water by 1° F. A barrel of crude oil has an energy content of 5.6 million Btu's; a gallon of gasoline 125,000 Btu's.

Table I  
ERDA Coal Liquefaction and Gasification  
Program Funding

<u>Fiscal</u> <u>year</u>	<u>Lique-</u> <u>faction</u>	<u>Gasification</u>		<u>Demon-</u> <u>stration</u> <u>plants</u>	<u>Total</u>
		<u>High Btu</u>	<u>Low Btu</u>		
----- (000 omitted) -----					
1974					
(note a)	\$ 45,500	\$ 33,300	\$ 22,100	\$ -	\$ 100,900
1975	94,745	59,805	49,993	-	204,543
1976					
(esti- mated)	89,912	53,364	24,552	31,900	199,728
Transition quarter					
(esti- mated)					
(note b)	26,443	9,250	6,720	7,750	50,163
1977					
(esti- mated)	73,946	45,054	33,052	53,000	205,052
1978					
(esti- mated)	125,100	64,600	52,800	50,000	292,500
1979					
(esti- mated)	143,500	61,100	36,000	43,000	283,600
1980					
(esti- mated)	153,700	33,700	42,700	88,000	318,100
1981					
(esti- mated)	<u>125,000</u>	<u>27,300</u>	<u>35,900</u>	<u>103,000</u>	<u>291,200</u>
Total	<u>\$877,846</u>	<u>\$387,473</u>	<u>\$303,817</u>	<u>\$376,650</u>	<u>\$1,945,786</u>

a/Department of the Interior figures.

b/The transition quarter is the period caused by the changing of the start of the Federal fiscal year 1977 from July 1, 1976, to October 1, 1976.

Development of a coal conversion process generally proceeds through the following stages, although ERDA could overlap or skip stages to accelerate the pace.

<u>Stage</u>	<u>Tons of coal converted a day (note a)</u>	<u>Typical time to complete a stage (years)</u>
Laboratory unit and bench scale unit	less than 10	1 to 4
Process development unit	10 to 100	4 to 6
Pilot plant	100 to 1,000	5 to 8
Demonstration plant	1,000 to 10,000	8 to 12

a/ These amounts are examples which offer perspective as to the relative scale-up from stage to stage; they do not necessarily reflect any one given process stage now under development. In fact, ERDA describes some 35- to 70-ton-a-day facilities as pilot plants.

In contrast, a commercial plant may convert about 25,000 tons of coal a day. ERDA believes that a process should be able to proceed from the laboratory to completion of demonstration in 15 to 20 years.

ERDA's cost-sharing strategy is to have industry fund one-third of the construction and operation costs for pilot plants and one-half for demonstration plants. Initial research stages, such as laboratory scale research, as well as pilot and demonstration plant design, are usually fully funded by ERDA.

These funding levels are not set by law or Federal regulations. Cost-sharing guidelines are set forth in a Federal Management and Budget Circular, dated December 4, 1973. This circular states that cost participation by commercial or industrial organizations, could reasonably range from as little as 1 percent or less of the total project cost to more than 50 percent of the total project cost.

Although flexibility is provided in the cost-sharing guidelines, ERDA has continued a cost-sharing strategy of obtaining about one-third industry contributions for new pilot plant projects and about one-half for demonstration plant projects. This is apparently based on discussions with the Office of Management and Budget.

A 1973 draft document from the Department of the Interior presents reasons for establishing a set percentage for cost participation. It states that flexibility in a contract research program is not practical. It also states that the main problem is that negotiating pressures tend to force the agreement to the lowest possible level of industry cost-sharing.

ERDA and Office of Management and Budget officials told us that some cost sharing is desirable because, among other things, it reduces risk and improves the probability of success, since industry would hesitate to attempt high-risk operations when it invests some of its own money.

#### STATUS OF ERDA-SUPPORTED SECOND-GENERATION LIQUEFACTION PROCESSES

Technology for converting coal to 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. At the present time, however, there appears to be only one commercial plant producing liquid fuels from coal. Details on this plant, which is located in South Africa, are presented in appendix I.

Coal liquefaction is the process of converting coal into a liquid fuel. There are several different methods for producing clean liquid fuels from coal. Some processes burn coal, condense the resulting gases, and add hydrogen to form a liquid, whereas other processes chemically dissolve coal with hydrogen to form a liquid.

The objectives of ERDA's liquefaction research and development program include:

- Developing and demonstrating, in cooperation with industry, second-generation processes necessary to construct commercial-scale plants by 1982-85.
- Providing incentives required to promote large-scale commercial production by private industry beginning in 1985 and achieving by that time a

production rate of 500,000 barrels a day of synthetic liquid fuel. 1/

On January 1, 1976, ERDA was funding five liquefaction processes which were beyond the basic research stage (1 ton a day or larger). Summary information on these processes is presented in the following table, while more detailed information is presented in appendix II.

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1/ These objectives were included in an ERDA document dated July 10, 1975. An ERDA draft document dated November 24, 1975, revises the oil production goal for second-generation liquefaction processes to 100,000 barrels a day by 1985. The Director of ERDA's Office of Coal Conversion and Utilization told us that 100,000 barrels a day is a more realistic figure.



Table 2

ERDA-Funded Liquefaction Projects

<u>Process</u>	<u>Current plant phase</u>	<u>Obligations to 1/31/76</u>		<u>Total estimated cost</u>		<u>Anticipated completion of current phase</u>
		<u>Government</u>	<u>Private</u>	<u>Government</u>	<u>Private</u>	
------(000 ommited)-----						
H-coal	600-ton-a-day pilot plant under design; operation planned for July 1978.	\$10,581	\$1,992	\$114,690	\$ 49,500	1981
Synthoil	10-ton-a-day plant (process development unit) starting construction; operation planned for July 1977.	22,009	--	44,962	1,090	1979
Solvent-refined coal	50-ton-a-day pilot plant operating since September 1974.	47,305	--	139,961	a/--	1981
Char-oil energy development	36-ton-a-day pilot plant completed operations in November 1974.	23,768	--	23,768	a/--	(b)
Coalcon	2,600-ton-a-day demonstration plant under design; operation planned for February 1979.	5,200	--	129,836	107,386	1983

a/ Contracts for these projects were signed before the cost-sharing policy was established.

b/ Plant dismantling should be started during 1976. No other plants are planned using this process.

The so-called Coalcon process is the most advanced of the five liquefaction projects ERDA funds. It is the only process in the demonstration phase of development.

#### Liquefaction demonstration program

In June 1974, the Office of Coal Research requested that private industry submit proposals for building a demonstration plant. The office had hoped to award more than one contract for the first two phases of this project. During these phases an economic assessment of a future commercial plant, detailed process designs, and a demonstration plant design were to be completed. By awarding more than one contract, the Office of Coal Research would have had the opportunity to select from a number of designs the most promising process or processes.

However, only three proposals were submitted, of which only one, Coalcon, met the requirements of the request. A much larger number of responses had been anticipated. Further, some firms which were considered to be among the best qualified for such work, and who were expected to submit a proposal, did not respond.

ERDA and/or industrial representatives indicated that the lack of response to the request was caused by factors such as:

- Unwillingness to spend in excess of \$100 million on a precommercial plant.
- Serious response to the request required an extensive work effort which has been estimated to cost in excess of \$500,000.
- The patent requirements were too restrictive.
- The Government was going to have excessive control over the project.
- The requirement that industry must buy the plant at the completion of the project.
- Other reasons included lack of sufficient time to respond, disagreeing with the emphasis on liquid product requirements, requirement for a large plant size, and emphasis on eastern coal.

On January 17, 1975, the Office of Coal Research awarded a \$237 million contract to the Coalcon Company. Coalcon is a joint venture of Union Carbide Corporation and Chemical

Construction Company. Coalcon formed a 14-member consortium which is to contribute industry's share of the costs. Coalcon representatives said that each member has signed a letter of intent indicating their willingness to participate in the project.

Coalcon will design, construct, and operate the expected 2,600-ton-a-day demonstration plant. A commercial size Coalcon plant could be composed of a number of reactor vessels, each about the size of the reactor to be used in the Coalcon demonstration plant. The Coalcon plant, as well as planned gasification demonstration plants, is expected to use a near commercial-scale reactor vessel and the necessary commercial support equipment. According to ERDA officials, if the demonstration plant proves successful, it could be scaled-up to commercial size with relatively little technical risk.

The Coalcon plant is expected to produce approximately 3,900 barrels a day of liquid product and the equivalent of 3,900 barrels of oil a day of pipeline quality gas. The expected output for each ton of coal is about 1-1/2 barrels of oil and 8,500 cubic feet of gas (the equivalent of 1-1/2 barrels of oil).

The demonstration project is currently in phase I, preliminary design. ERDA and Coalcon are now working to overlap the subsequent phases where possible to save time. A site near New Athens, Illinois, has been selected over 15 other sites. Plant construction is scheduled to begin in June 1977, with plant operation to begin in February 1979. The demonstration plant is to be operated for about 3-1/2 years.

ERDA will pay the cost of the design phases, I and II, of the contract. Coalcon will contribute 50 percent of the costs incurred in phases III and IV (constructing and operating the plant).

#### STATUS OF ERDA-SUPPORTED SECOND-GENERATION GASIFICATION PROCESSES

Gas made from coal was once widely used in the United States. It has only been about 20 years since U.S. utilities shifted from coal to natural gas. Processes used to manufacture coal gas were crude, inefficient, and costly, and gas output from plants using these processes was low. Some processes are still commercially available and are being used, mostly in other countries, to produce low- and medium-Btu gas from coal. These first-generation processes are discussed more fully in appendix I.

In coal gasification processes, the coal is fed into a high-temperature vessel, called a gasifier, into which steam and either air or oxygen are injected. Chemical reactions occur and a mixture of gases is produced; these usually 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 sulphur are removed.

The raw gas, produced at this point, is referred to as low-Btu gas if produced with air, and medium-Btu gas if produced with oxygen. This gas has a low or medium heat value (less than 450 Btu's a cubic foot) and cannot be economically transported over long distances by pipeline. It is valuable, however, as a fuel supply for electrical power generation plants or industrial processes using gas-fired furnaces which are located near the conversion plant. Low- and medium-Btu gas plants are in commercial use today, some of which are based on technology developed in Europe about 40 years ago.

Low- and medium-Btu gas can be upgraded to a high-Btu gas (950 to 1,000 Btu's a cubic foot) through a reaction between hydrogen and carbon monoxide, referred to as methanation. High-Btu synthetic gas is a substitute for natural gas and can be transmitted in existing pipeline networks to satisfy the demands of present natural gas users.

The objectives of ERDA's high-Btu gasification program are to:

- Develop and demonstrate, in cooperation with industry, by 1982 new and improved technology necessary to construct commercial-scale plants, which convert domestic coal into synthetic pipeline gas.
- Provide incentives required to promote large-scale commercial production of synthetic pipeline gas by private industry beginning in 1985 and to achieve by 1990 a production rate of the equivalent of more than 500,000 barrels of oil a day. <sup>1/</sup>

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<sup>1/</sup> These objectives were included in an ERDA document dated July 10, 1975. An ERDA draft document dated November 24, 1975, revises the production goal for second-generation technology. A goal of the equivalent of 300,000 barrels of oil a day is established for high-Btu gasification and 250,000 barrels for low-Btu processes by 1985.

The objectives of ERDA's low-Btu program are to:

--Develop and demonstrate, in cooperation with industry, improved technology necessary for constructing commercial-scale plants for processes which convert domestic coal to environmentally acceptable substitute gaseous fuels for conventional boilers, other industrial applications and chemical feedstocks, and later for advanced systems to generate electrical power. The target date for completion is 1981.

--Provide incentives required to promote large-scale commercial production and utilization of low-Btu gas by private industry beginning in 1987. 1/

As of January 1, 1976, ERDA was funding five second-generation processes beyond basic research aimed at producing high-Btu gas, and one project aimed at producing the hydrogen needed to make high-Btu gas. In the low-Btu gas area, ERDA was funding seven processes that were beyond basic research. None of these processes has yet completed the pilot plant phase. Summary information on these ERDA-funded processes is included in the following table and more detailed information on selected processes is presented in appendix II.

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1/ See footnote on p. 14.

Table 3

ERDA-Funded Coal Gasification Projects

<u>Process</u>	<u>Current plant phase</u>	<u>Obligations to 1/31/76</u>		<u>Total estimated cost</u>		<u>Anticipated completion of current phase</u>
		<u>Government</u>	<u>Private</u>	<u>Government</u>	<u>Private</u>	
----- (000 omitted) -----						
High Btu:						
Hygas	75-ton-a-day pilot plant operating since October 1971.	\$34,251	\$ 9,401	\$38,511	\$12,105	1977
Steam iron (hydrogen producing technique)	Pilot plant under construction; operation planned for October 1976.	9,510	5,192	39,090	19,495	1978
Synthane	72-ton-a-day pilot plant is scheduled to start operation in May 1976.	27,350	--	68,250	--	1978
Carbon dioxide acceptor	40-ton-a-day pilot plant operating since October 1972.	29,199	7,330	37,720	12,080	1977
Bi-gas	120-ton-a-day pilot plant under construction; operation planned for June 1976.	33,465	12,461	90,507	43,290	1978

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<u>Process</u>	<u>Current plant phase</u>	<u>Obligations to 1/31/76</u>		<u>Total estimated cost</u>		<u>Anticipated completion of current phase</u>
		<u>Government</u>	<u>Private</u>	<u>Government</u>	<u>Private</u>	
----- (000 omitted) -----						
Self agglomerating ash	25-ton-a-day process development unit starting operations May 1976.	\$ 6,788	\$ 569	\$16,964	\$ 569	1978
Low Btu:						
Molten Salt	Contract is being re-negotiated to reduce plant size to 24-ton-a-day.	4,611	1,784	5,830	2,783	1979
Westinghouse fluidized bed	14-ton-a-day plant starting operations in March 1976. (note a)	15,696	4,167	<u>b</u> /22,794	<u>b</u> /6,726	Open
Morgantown Energy Research Center fixed bed	24-ton-a-day plant in operation since 1968.	3,622	--	15,910	--	1977
Slagging fixed bed	25-ton-a-day pilot scale gasifier under construction. Operation is scheduled to start in September 1977.	800	--	4,650	--	1979

<u>Process</u>	<u>Current plant phase</u>	<u>Obligations to 1/31/76</u>		<u>Total estimated cost</u>		<u>Anticipated completion of current phase</u>
		<u>Government</u>	<u>Private</u>	<u>Government</u>	<u>Private</u>	
----- (000 omitted) -----						
Bituminous Coal Re-Search fluidized bed	1-ton-a-day plant completed construction December 1975. Shake down operations are now underway.	\$ 2,575	\$ --	\$ 3,725	\$ --	1977
Combustion Engineering en-trained bed	120-ton-a-day plant under construction. Operation planned to start in June 1977.	13,739	6,870	14,239	6,870	1979
Foster-Wheeler combined cycle	480-ton-a-day plant in design phase. Project to be discontinued at end of work on current contract.	6,250	2,895	6,250	2,895	1976

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a/ Only one section under operation. Complete plant operation scheduled for early 1978.

b/ Through fiscal year 1977, at which time a decision will be made on whether or not to continue the project.



High-Btu gasification  
demonstration project

On October 3, 1975, ERDA requested that private industry submit proposals to design, construct, and operate a high-Btu gas demonstration plant of sufficient size to demonstrate commercial feasibility. The request called for a three-phased development program with the Government funding all of phase I (design) and 50 percent of phases II (construction) and III (operation). An ERDA official told us that some estimate the cost of responding to this request at about \$150,000 to \$300,000. ERDA anticipates making one or more awards for phase I and later selecting the process or processes it wishes to demonstrate.

ERDA received five responses to the request. We obtained the following information from these companies on their proposed projects.

<u>Respondent</u>	<u>Process</u>	<u>Capacity</u>	<u>Plant location</u>
Conoco Coal Development Co.	Slagging Lurgi	3,800 tons a day	Ohio
Illinois Coal Gasification Group	Cogas	2,000 tons a day	Illinois
Ken-Tex Energy Corp.	Hygas	7,300 tons a day	Kentucky
Wheelabrator Frye Inc.	Synthane	2,300 tons a day	Alabama
Wycoalgas Group	Texaco	4,500 tons a day	Wyoming

ERDA is now evaluating the proposals and anticipates awarding phase I contracts by June 30, 1976. Presently, ERDA has authorization for a single high-Btu coal gasification demonstration plant. It plans to request congressional authorization for a second plant in its fiscal year 1978 budget.

The demonstration program has an 8-year work schedule. Phase I, design, is to be completed 20 months after the award of the contract. Phase II, demonstration plant construction, is scheduled for 34 months. Phase III, operation of the plant, is scheduled to run for 42 months.

## Low-Btu gasification demonstration program

On February 5, 1976, ERDA requested private industry proposals for low-Btu gasification demonstration plants. The request calls for bids on a three-phase program of design, construction, and operation of three types of plants: utility, industrial, and small-scale industrial. The utility plant is to demonstrate the production of fuel gas from coal for use by electrical utilities. The industrial plant is aimed at demonstrating the ability to use the fuel gas produced by second-generation processes in an industrial application. The small-scale industrial plant is aimed at demonstrating a process using first- or second-generation technology with a gas cleanup system for general use by small-scale users.

ERDA anticipates making more than one award for the design phase for each type of plant and later selecting the process or processes which will continue to the construction phase. Presently, ERDA is authorized to begin the construction phase for the utility project. Congressional approval and funding is necessary before ERDA begins the construction phase for the industrial and small-scale plants.

The demonstration program for the utility and industrial plant projects is expected to last 6 years; about 4-1/2 years should be required for the small-scale industrial project. ERDA hopes to start awarding contracts under the program during August 1976.

## CONCLUSIONS

ERDA's research on advanced or second-generation processes is aimed at developing them in a time frame that permits production of synthetic oil and gas by 1985. No process has yet been operated on a demonstration scale, but ERDA believes that once this is achieved little technical risk should exist in scaling these demonstration plants up to commercial size. The liquefaction demonstration program is now in the preliminary design stage. ERDA has not yet awarded contracts for demonstration projects in the gasification area but expects to do so in mid-to-late 1976. Schedules for these projects show that, if the projects proceed as currently planned, the operation of the demonstration plants would not be completed until 1981-84.

Coal liquefaction and gasification processes still require considerable development and time before they will be available for commercial use. In fact, ERDA's goal for production from second-generation liquefaction plants by 1985 has already slipped considerably from its July 1975

projections. Assuming the current pace of development continues, the revised goals being drafted by ERDA may be difficult to achieve. In fact, it appears highly unlikely that any commercial-size coal liquefaction plant will be operating in the United States by 1985.

## CHAPTER 3

### CONSTRAINTS TO COMMERCIALIZING COAL CONVERSION TECHNOLOGY

The major commercial projects proposed in the United States to build plants to produce synthetic liquids or gas from coal have been in the high-Btu gasification area. As of January 31, 1976, three companies had submitted applications to the Federal Power Commission (FPC) for approval of high-Btu coal gasification plants. Each of these companies proposed using the Lurgi process with a methanation unit. Summary information on these applications is shown in the following table. At least 13 other companies have announced their intentions to build commercial high-Btu gasification plants but as of January 31, 1976, none have filed applications with FPC. (Appendix III lists these companies.)

This chapter focuses on the economic constraints and other considerations to commercializing coal conversion processes. Much of the information presented is based on the experiences of the three companies that have filed with FPC for high-Btu gasification plants using first-generation technology.

Table 4

High-Btu Coal Gasification Plant Applications  
Filed with the Federal Power Commission  
As of January 31, 1976

<u>Project sponsor(s)</u>	<u>Date of application</u>	<u>Gas output of proposed plant (million cubic feet a day)</u> (note a)	<u>Status</u>
El Paso: El Paso Natural Gas Co. (notes b and c)	11/15/72	288	On March 27, 1975, El Paso asked FPC to defer its decision pending resolution of certain matters relating to its coal lease. El Paso no longer predicts a project completion date.
WESCO: Pacific Lighting Corp. (note b) Texas Eastern Transmission Corp. (note b) Transwestern Coal Gasification Co. (note c) Transwestern Pipeline Co. (note c) Pacific Coal Gasification Co. (note c) Western Gasification Co. (note c)	2/7/73	250	On April 21, 1975, FPC approved WESCO's application with modifications. However, WESCO requested a rehearing. FPC issued an opinion on the rehearing on November 21, 1975. WESCO views this as an improvement but stated that Government loan guarantees are essential before financing can be secured. Construction was scheduled to start in early 1976, but has not.

<u>Project sponsor(s)</u>	<u>Date of application</u>	<u>Gas output of proposed plant</u> (million cubic feet a day) (note a)	<u>Status</u>
Michigan-Wisconsin: American Natural Gas Co. (note b) Michigan-Wisconsin Pipe- line Co. (note c) ANG Coal Gasification Co. (note c)	3/27/75	275	FPC hearing on application began January 22, 1976.

a/ One million cubic feet of gas equals about 180 barrels of oil. A 250 million cubic foot a day plant would produce the equivalent of about 45,000 barrels of oil a day.

b/ Controlling company.

c/ Applicant.

## RECENT FPC RULINGS AFFECTING COAL GASIFICATION

The Natural Gas Act of 1938 (15 U.S.C. 717) requires FPC authorization before a company can sell or transport natural gas in interstate commerce. FPC recently interpreted the act to mean that synthetic gas is not natural gas and is not subject to its jurisdiction unless the synthetic gas is commingled with natural gas in an interstate pipeline. In almost all cases, synthetic high-Btu gas will be commingled with natural gas. Low-Btu gas differs considerably from natural gas and will not be commingled.

FPC's jurisdiction covers transportation and sale of commingled synthetic gas but not the synthetic gasification plant itself. FPC authorization is needed to (1) build a connection assembly at the existing natural gas pipeline, (2) transport and sell the synthetic gas, and (3) set the rate which companies will be permitted to charge for the gas. WESCO believed that FPC should have authority over synthetic plants and contested the jurisdictional decision; however, the decision was sustained on July 28, 1975. 1/

Apart from the jurisdictional question, a second major regulatory issue has been a proposed "all events tariff." Both El Paso and WESCO wanted FPC to allow recoupment of all project costs plus a return on investment under all events, even if the plant was closed after a brief period of operation. FPC decided that the all events tariff WESCO proposed inadequately protected ratepayers. It devised a stronger provision which reduced rate of return as plant output decreased below a certain annual capacity factor. Plant production is not clearly established in the decision. An FPC official told us that if plant production fell to zero, no project costs could be passed to customers.

The effect of these FPC decisions on risk to an investor is considerable. In essence, it means that in cases where gas from a synthetic fuel plant is never linked to a pipeline or in cases where gas production ceases and the plant fails, the project investors have to absorb the losses. The losses cannot be passed on to customers. If FPC had allowed losses from failed plants to be passed on to customers, little risk would have accrued to investors.

The Public Utilities Commission of California has been involved in these proceedings since a large amount of the synthetic gas that would be produced by the plants would be sold

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1/ Alice Henry v. FPC, No. 74-1045, (D.C. Cir., July 28, 1975).

in California. The State commission agrees with WESCO that Federal assistance is essential before the facilities can be built. However, California has also urged that the Federal Government also guarantee the ratepayer that the cost of synthetic gas will not escalate above a certain level. A WESCO official said that their project is geared toward their California pipeline and that without a good indication that full costs could be passed on in California, they would probably not proceed with the project.

### ECONOMIC CONSTRAINTS

Underlying all discussions of what investments should be made is the basic question of economics, if capital is invested, is there the expectation of a reasonable return. Many factors must be assessed by both project sponsors and lenders to answer this important question. Among the most important are (1) capital requirements, (2) the impact of possible cost escalation and delays, (3) product competitiveness, and (4) technical risk.

#### Capital requirements

Liquefaction and gasification plants require large capital investments. The financial situation of many gas companies interested in building synthetic coal gasification plants is apparently not adequate to secure the loans required to build the plants. The average total assets of the 10 largest gas companies in 1974 was about \$2 billion, and these companies have relatively high ratios of debt to equity. The capital requirement for a high-Btu gasification plant is expected to approximate \$1 billion. For these companies, such an investment is considerable and most likely would only be made if there were reasonable assurance of a favorable return on investment in relation to risk. Since a high ratio of debt to equity tends to transfer the risk of a project to the lending institution, and a return on investment is not guaranteed, these institutions may be reluctant to loan funds.

Capital cost estimates for the three high-Btu projects with applications before FPC have increased enormously since the initial estimates. The following table shows the amount of these increases. The cost of the plant proposed by the El Paso Natural Gas Company equals about 50 percent of the company's total assets for a plant which would supply only about 14 percent of El Paso's estimated available natural gas for 1979. The capital cost increases for the other proposed projects are similar to those for the El Paso project.

An important factor affecting capital cost requirements is how the expense of costs incurred during construction,



Table 5  
High-Btu Coal Gasification Projects  
Capital Cost Estimates

<u>Project sponsor</u>	<u>Date when project completion and cost was estimated</u>	<u>Estimated project completion date</u>	<u>Estimated project cost (millions)</u>
El Paso Natural Gas Company	Aug. 1971	1976	\$250
	Nov. 1972	1976	353
	Oct. 1973	1978	491
	Dec. 1975	(a)	(Approximately \$1 billion)
WESCO	Feb. 1973	b/1979	406
	June 1974	1979	447
	Jan. 1975	(c)	853
Michigan-Wisconsin	Mar. 1974	1980	450
	Apr. 1975	1980	d/778

a/ El Paso no longer projects a specific completion date other than it would occur 3 to 3-1/2 years after the date when all necessary approvals were obtained and financial arrangements completed.

b/ An earlier estimate projected that the plant could become operational in 1977.

c/ Construction was scheduled to begin in early 1976, but has not. WESCO currently claims that its project cannot proceed without Government incentives.

d/ Does not include capitalized interest during construction, which is expected to be provided on a current basis through a surcharge to Michigan-Wisconsin Pipeline Co. customers. This is subject to FPC approval.

such as interest on borrowed money and return on equity, is handled. Sponsors of the Michigan-Wisconsin project have proposed assessing a surcharge, during the construction period, on Michigan-Wisconsin Pipeline Company's gas customers. This would reduce the capital requirement for the Michigan-Wisconsin gasification plant by over \$400 million (in escalated dollars). It is Michigan-Wisconsin's position that FPC must authorize this surcharge during the construction period if gasification plants are to be financed. While neither El Paso nor WESCO has proposed a surcharge to cover funds used during construction, officials from both companies indicated their interest in doing so, should FPC approve the Michigan-Wisconsin proposal.

These companies are now holding discussions with financing institutions; the prospects for success are not good. The financial consulting firms of Morgan Stanley and Company and Dillon, Read and Company concluded that the WESCO project was not financeable under the conditions set forth in the April 21, 1975, FPC decision. Morgan Stanley noted that the anticipated capital costs are large in relation to the companies' capitalization and lenders would be concerned that the sponsoring companies could not handle foreseeable project losses. First National City Bank of New York, a potential project investor, concluded that it does not wish to participate in the financing arrangements because FPC decisions did not allow recovery of total costs in all cases and did not provide investor guarantees in cases where the plant is not completed. On October 20, 1975, Dillon, Read and Company concluded, in testimony before Congress, that Government assistance and changes in regulatory policy will be required for regulated natural gas companies to accomplish the financing of high-Btu coal gasification projects.

After these financial studies were made, a modified FPC decision was issued on November 21, 1975. Although this decision is more favorable to project sponsors, it does not appear to change the major reasons for the conclusions of these financial groups. Essentially the modified decision increased the price which could be charged to customers and attempted to assist the financeability of the project. WESCO currently claims that its project cannot be financed without Government guarantees. El Paso and Michigan-Wisconsin officials told us that Federal guarantees are desirable and might be necessary.

For liquefaction projects, the need for large amounts of capital is also great. South Africa's second commercial liquefaction plant will produce the equivalent of about 50,000 barrels of oil a day and is being sponsored by the South African Government. The project is estimated to cost \$1-1/2

2 billion. The South African project will be funded from three principal sources: a fund fed by fuel users, export credit finance, and moneys voted by the South African Parliament.

An important distinction regarding the capital requirement for building coal liquefaction plants in comparison with gasification plants is that, while interest in gasification technology is evident mainly among gas companies, major oil companies have expressed interest in liquefaction technology. For example, two interested oil companies, Exxon and Gulf, had total assets of \$31.3 billion and \$12.5 billion, respectively, in 1974 and low debt-to-equity ratios. Thus, it appears that these companies are in a better financial position to raise the necessary capital than is the gas industry.

#### Capital requirements as they affect the Nation's economy

The Federal Energy Administration, along with several banking institutions and consulting firms, has studied the availability of funds and the methods of financing the capital requirements for a number of energy investments, including coal conversion processes, over the next 10 to 15 years. The consensus of these studies is that the capital markets will be able to meet the energy investment demands if the mix of energy investment to total business investment remains in the same general proportion as in the past. Further, these studies show that the other sectors of the economy will not be greatly affected in competing for available funds.

#### Cost escalation and schedule delays

Investors and project sponsors are wary of the validity of cost estimates and construction plans and schedules. The experience of the three high-Btu gasification plant applicants gives credence to this concern. Since the El Paso Natural Gas Company first applied to FPC in 1972, its project cost estimate has risen from \$353 million to approximately \$1 billion. Cost escalation has affected the WESCO and Michigan-Wisconsin projects in a similar manner. According to El Paso officials, their project's major problem was inflation, with some equipment items doubling in price during this time. This was compounded by design changes made by El Paso which also increased the project's cost.

Project schedules for each of the proposals are very tentative, depending ultimately on obtaining many Federal, State, local, and Indian tribe approvals and agreements, and on securing financing. The schedule in El Paso's case is so

uncertain that the company no longer predicts a construction start date.

### Product competitiveness

The possibility that the Government's position might change about reliance on foreign imports, or that a synthetic fuel will not be competitive with new energy supplies, or that a synthetic fuel's selling price will not provide a good investment return, are among the most important product-price-related considerations that must be evaluated.

The Arab oil cartel has the ability to undercut synthetic oil or gas prices, raise prices, or cut back supplies. Regardless of what actions are taken by the cartel, synthetic fuels must be able to compete with conventional supplies, particularly the price of imported oil. An analysis presented in the Synfuels Interagency Task Force report implied that under normal investment and risk circumstances, market forces are likely to cause the introduction of synthetic fuels between 1985 and 1990. This timetable could be moved up if the cartel increases prices or cuts off supplies, or could be dropped back if import prices fall. Until synthetic fuel prices become competitive with conventional supplies or until Government assistance is introduced, it is unlikely that industry will take the initiative to build liquefaction plants.

The gas industry is somewhat different because of its regulated nature. Synthetic gas, mixed in an interstate natural gas pipeline, may be priced by either the incremental or the "rolled in" pricing method. Coal gasification plant sponsors are opposed to incremental pricing, which requires those customers who receive the synthetic gas to pay the full cost of production and delivery. They favor rolled in pricing which means that the cost of producing and delivering the synthetic gas will be charged to customers on a rolled in or averaged basis. For example, El Paso has estimated that, initially, its synthetic production will constitute about 11 percent of the total quantity being pipelined to their customers. Thus, 89 percent of the product price would be based on the natural gas cost and 11 percent on the synthetic gas price (about \$3.00 a million Btu). El Paso has projected that by rolling in the price of the synthetic gas with natural gas, the initial price increase to the homeowner would be about \$.27 a million Btu. There is much controversy as to which pricing method will be approved by FPC. However, even if rolled in pricing is approved, State public utility commissions might limit these charges from being passed on to customers.

The following table offers perspective as to the competitiveness of estimated synthetic fuel prices. It should be noted that although products from coal liquefaction and gasification processes would primarily be used to replace conventional oil and gas, these processes could also be used to produce other products, such as ammonia or methanol.

Table 6

Comparison of Actual and Estimated U.S. Prices for  
Natural and Synthetic Gas and Oil

\$ for each million Btu

Gas:

Natural:		
Regulated (new interstate gas)		\$0.52
Unregulated (intrastate)		1.80
Synthetic high Btu:		
El Paso		2.83-3.00
Michigan-Wisconsin	a/	3.13
WESCO		3.00 +
Liquefied natural gas (imported)		2.40-2.60
Synthetic low Btu	b/	3.10-3.50

Oil:

Natural:		
Domestic		.94-2.01
Imported		2.25-2.45
Synthetic		3.71-4.58

a/ This estimate reflects a surcharge against present customers during the construction period. Without such a charge, it would be higher.

b/ These estimates are based on small capacity plants. Low-Btu gas could also be used in large plants as utility fuel with a decrease in product cost. Also low-Btu gas would be used at or very near the plant site, whereas high-Btu gas would usually incur the additional cost of being pipelined to users.

Technical risk

Officials of the three companies which have applied to FPC to build high-Btu coal gasification plants said that lenders are reluctant to finance plants partly because the lenders are skeptical of technical success. Energy Research and Development Administration (ERDA) officials, as well as

involved industry officials, told us that the technical risks of proposed gasification plants (using Lurgi with methanation) are minimal. About 14 Lurgi plants are operating outside the United States, and the methanation step has been proven on a Lurgi gasification unit at Westfield, Scotland. Of the 16 announced high-Btu gasification projects, only 8 have identified what process they intend to use; all 8 plan on using Lurgi with methanation.

## OTHER CONSIDERATIONS

### Coal availability

Most U.S. coal is found west of the Mississippi River, far from the concentrated industrial areas of the East and Far West--major markets for coal. Nearly all the coal lands and reserves in the West are owned principally by the Federal Government.

Two announced coal gasification projects have experienced problems in obtaining and maintaining rights to coal reserves. A Northern Natural Gas Company official said that they might withdraw from their commitment to build a coal gasification plant in Montana. One of the main reasons for the decision is that rights to the coal reserves from the Cheyenne Indian Reservation, the source of coal for the plant, are being questioned. When the El Paso Natural Gas Company decided to build a coal gasification plant, it planned to use coal rights from a lease signed with the Navajo Indian Tribe in New Mexico. In 1974, El Paso realized that its project would be delayed beyond December 2, 1978, the final date to start production under the existing lease. El Paso negotiated with the Navajo Tribe to secure certain waivers and to extend the expiration date of the lease. The Navajo Tribal Council has still not approved a proposed new lease which should correct ambiguities in the existing lease. After it is approved by the tribal council, it must be approved by the Secretary of the Interior.

The task force concluded that problems in mining, transportation, and environment do exist and that there are potential actions on the Federal and State levels, such as passage of stringent strip mining legislation, that can seriously disrupt the development and extraction of certain specific coal reserves. However, in general, the task force could see no set of circumstances that would cause availability of our coal reserves to be a constraint, even on a significantly accelerated production schedule.

## Water availability

The question of water availability for widespread coal conversion development is an important and complex issue. Many believe that water will become more polluted and diverted from other uses. The task force report states that with complete development of water resources and careful allocation, enough water will be available in all regions except the southern Rocky Mountains. Further study must be given to the effects of a widespread coal conversion industry on water availability. Until this is resolved, the water availability question will be answered on a plant-to-plant basis.

Presently, industry must obtain approvals from various sources before water use is permitted. Approvals needed may vary from site to site but can include approvals from the Department of the Interior's Bureau of Reclamation, Corps of Engineers, and/or State governments.

The water usage expected for the El Paso project amounts to about 9.4 million gallons a day, or 6,528 gallons a minute; the water requirements for the WESCO project amount to about 7.1 million gallons a day, or 4,930 gallons a minute.

Liquefaction processes are expected to have water requirements comparable with gasification processes. Water requirements vary widely depending on what process and support equipment are used.

## Equipment and materials

Some of the largest equipment (rectisol absorbers) to be used in proposed first-generation projects, such as the El Paso Natural Gas Company project, are expected to be 206 feet high, have a diameter of 13-1/2 feet, and weight 436 tons. Lurgi gasifiers are 25 feet high, 13-1/2 feet in diameter, and weigh 150 tons each. The El Paso Natural Gas Company's plant design requires 34 gasifiers. These gasifiers can be shop fabricated and transported to the plant site.

Second-generation coal conversion facilities will require even larger pieces of equipment. For example, the main piece of equipment (a gasifier) for one of the conversion processes 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 able to withstand temperatures of 2,000° F and pressure of 1,000 to 1,200 pounds a square inch over long periods of time. Second-generation plants are expected to require only two or three gasifiers. An ERDA official told us that this equipment probably will not be able to shop fabricated.

In our review of reports on energy-related matters, as well as in discussions with individuals involved in coal research, concern was evident over the ability of private industry to fabricate and erect the equipment required for many commercial coal-processing plants. A major concern is the shortage of raw materials and experienced labor in the United States to produce the thick-walled pressure vessels used in all coal conversion processes. The current backlog at pressure vessel fabrication shops is 12 months or longer.

The Project Independence report 1/ notes that current energy development has been slowed by shortages of certain categories of equipment. It also notes that future development of all energy resources 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 capacity of the construction industry to build energy-related facilities are two constraints set forth in the Project Independence report, which have particular applicability to coal-related energy research. The report states that expansion of domestic steelmaking capacity is important to increased energy development. With respect to construction of energy facilities, the report states that this constraint is not severe but that the availability of capital, material, and labor shortages could affect the ability of the construction industry to expand to the needed capacity.

### Coal Transportation

About 85 percent of the coal produced in the United States is transported to usage sites by rail and/or barge. Increasing the production and use of coal will require that the transportation network be able to increase its capability to meet new demands over a short period of time.

Coal transportation does not appear to be a serious constraint at this time. The three coal gasification companies, which have applied to FPC, have located their plants adjacent to their coal supply, thus reducing transportation requirements and expenses. Future coal conversion projects should do this to the maximum extent.

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1/ "Project Independence Blueprint, Final Task Force Report: Synthetic Fuels from Coal," Federal Energy Administration, Nov. 1974.



The task force concluded that if the railroad and waterway networks continue to operate at current utilization rates and are expanded at rates commensurate with their internal and presently planned capabilities, they will not be able to transport even the lowest level of projected increases in coal production. If, on the other hand, they were to operate at maximum theoretical capacities and expand at higher rates, they could, after initial adjustment, support almost any foreseeable increases in coal production.

#### Social constraints

A problem which must be answered before widespread commercialization takes place is the effect of these plants on the area surrounding the plant site. Many coal conversion plants are expected to be built in a somewhat rural setting close to the coal supply. The effect of these plants on an area could be the so-called boom town effect. Questions to be answered deal with expected local inflation, local public opinion about the plant, increased demand on local schools, stores, roads, waste facilities, water, police and fire protection, and other important services. Financing the services to meet these increased demands could also be a problem. Both El Paso and WESCO are studying these questions.

The task force program states that up to \$350 million of financial assistance might be necessary in planning for and mitigating socioeconomic impacts.

#### Possibility of Government incentives

It is difficult to determine a company's willingness and ability to finance coal conversion plants without recognizing their awareness of possible Government action. Bills which the Congress is discussing and a program which ERDA is planning are intended to facilitate financing coal conversion plants.

Whether or not a private company would independently secure financing for a billion dollar investment at a time when Government assistance may be around the corner is difficult to ascertain. However, the very fact that Government action in this area is uncertain might be a major constraint.

#### Effect of natural gas deregulation

Price deregulation is not expected to be the answer to the natural gas shortage because natural gas supplies are limited. It is expected to lessen the short-term supply problem. To this extent, deregulation would lessen the need to build the synthetic plants.

## Environmental impact

The task force prepared a draft environmental statement for various synthetic fuels technologies including coal liquefaction and gasification. The task force concluded that because commercial-size plants have not been built in the United States, uncertainties exist as to the impacts from such production. These uncertainties include such things as amounts and types of emissions and effluents generated and precise water requirements. ERDA and other Federal agencies plan to monitor and study the early commercial plants during the first phase of the commercialization program.

## CONCLUSIONS

ERDA's "National Plan for Energy Research, Development, and Demonstration" (June 1975) predicted contributions of 2-1/2 million barrels of oil a day by 1985 from first-generation coal liquefaction processes and the equivalent of 1/2 to 1-1/2 million barrels of oil a day from first-generation coal gasification processes. Today, less than 1 year after these projections were made, it is obvious that they were grossly optimistic. ERDA is preparing a revision to the June plan, and this draft document no longer projects a production goal from coal liquefaction processes by 1985 and projects the equivalent of between 250,000 to 500,000 barrels of oil a day from coal gasification processes. The constraints evidenced during efforts to commercialize coal gasification technology, such as capital requirements, cost escalation, regulatory decisions, and price competition could interact in a manner which would make even ERDA's revised draft gasification goal difficult to achieve.

Three first-generation high-Btu coal gasification projects have reached the point where applications have been submitted to the Federal Power Commission. The experience of these first efforts to commercialize this technology in the United States illustrates the severity of several problems which sponsors must face and which have precluded the scheduled advancement of their projects. In fact, El Paso Natural Gas Company, one of three companies to apply to the Federal Power Commission, no longer predicts a construction start date, a good indication of the uncertainty surrounding these efforts.

A major problem is the prolific advancement and enormity of project costs. In 1973, WESCO projected capital costs of \$406 million; in January 1975, less than 2 years later, this estimate was revised to \$853 million.

Sponsors of the WESCO coal gasification project said that the project cannot be financed in the private sector without Federal Government financial support. Financial advisors to this project essentially agree with the WESCO position. The status of other high-Btu gasification projects appears equally tenuous although not all have unequivocally stated that Government assistance is essential.

FPC refused to allow project sponsors to pass costs on to customers in all cases, which means that investors must accept the risk that, in some cases, their moneys might be lost. Consequently, the ability of the gas companies to secure investments of this size (\$1 billion) may be inadequate. Also, State public utility commissions might not allow the high cost of synthetic gas to be passed on to customers in their States unless the Federal Government guarantees that the price will not rise above a specified level.

The Synfuels Interagency Task Force recommended that the Government provide loan guarantees for initial high-Btu gasification projects. In our opinion, the views expressed by regulatory agencies indicate that regulatory changes or Federal subsidies might be needed in addition to loan guarantees.