

Y 4
. In 8/13
92-15

92 Y 4
In 8/13
92-15

REVIEW OF THE DEVELOPMENTS IN COAL GASIFICATION

GOVERNMENT
Storage

HEARING BEFORE THE SUBCOMMITTEE ON MINERALS, MATERIALS, AND FUELS AND THE FULL COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE

22E202 009TTA
11600

Pursuant to S. Res. 45
A National Fuels and Energy Policy Study
NINETY-SECOND CONGRESS

FIRST SESSION
ON

THE DEVELOPMENTS IN COAL GASIFICATION AND S. 1846, A
BILL TO ESTABLISH A COAL GASIFICATION
DEVELOPMENT CORPORATION

NOVEMBER 18, 1971

Serial No. 92-15



Printed for the use of the
Committee on Interior and Insular Affairs

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1972

70-869 O

CONTENTS

	Page
S. 1846-----	2
Department of the Interior report-----	11
Office of Management and Budget report-----	12
Office of Science and Technology report-----	12
Excerpts:	
Department of the Interior message to Committee on Interior and Insular Affairs-----	25
President's Clean Energy Message, June 4, 1971-----	23
Speech by Hollis M. Dole before American Bar Association, July 6, 1971-----	34

STATEMENTS

Dole, Hollis M., Assistant Secretary for Mineral Resources, Department of the Interior-----	18
Ewing, George H., vice president, Texas Eastern Transmission Corp., ac- companied by Alexander M. Wilson, president, Utah International, Inc.; and Harvey Proctor, president, Pacific Lighting Corp-----	56
Lawrence, George H., vice president and director, American Gas Associa- tion-----	49
Randolph, Hon. Jennings, a U.S. Senator from the State of West Virginia--	16
Reed, Sherman K., director, central research department, FMC Corp-----	67
Strieff, David T., senior vice president, Northern Illinois Gas Co-----	73
Walsh, Edward A., vice president, El Paso Natural Gas Co-----	37

APPENDIX

Agreement between Department of the Interior and American Gas Associa- tion for Cooperative Coal Gasification Research Program-----	75
Correspondence and material submitted by Senator Randolph:	
"Coal Gasification/Advanced Power Cycle," Environmental Protection Agency-----	86
Jackson, Hon. Henry M.: Letter to William D. Ruckelshaus, dated Nov. 30, 1971-----	84
Kearns, Charles M., Jr., United Aircraft Corp.: Letter to Hon. Henry M. Jackson, dated Dec. 16, 1971-----	111
Ruckelshaus, William D., Environmental Protection Agency, Washing- ton, D.C.: Letter to Hon. Henry M. Jackson, dated Dec. 28, 1971-----	84
The Technological and Economic Feasibility of Advanced Power Cycles and Methods of Producing Nonpolluting Fuels for Use in Utility Power Stations-----	112
Questions submitted by Senator Hansen to Edward A. Walsh-----	79
Questions submitted by Senator Randolph to the Department of the Interior-----	75
Rice, Theron J., Continental Oil Co., Washington, D.C.: Letter to Senator Jackson, dated Nov. 18, 1971-----	78

REVIEW OF THE DEVELOPMENTS IN COAL GASIFICATION

THURSDAY, NOVEMBER 18, 1971

U.S. SENATE,
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The committee met pursuant to notice at 9 a.m., in room 3110, New Senate Office Building, Senator Frank E. Moss, presiding.

Present: Senators Moss, Hansen, Hatfield, Jordan of Idaho, Fanin, Anderson, Randolph (chairman, Public Works Committee).

Also present: Jerry T. Verkler, staff director; William J. Van Ness, chief counsel; Mary Jane Due, staff counsel; and Charles Cook, minority counsel.

Senator Moss. The hearing will come to order.

I expect there will be more of my colleagues along shortly. These are rather crowded days around here and it is difficult for the Senators to meet all of their obligations. We do want to get the hearing started because of the need to move along as expeditiously as possible.

The Senate is in session already this morning and the prospects of a vote looms by 10 o'clock. Undoubtedly, there will be some delays along the way during the hearing.

This is a hearing this morning on the development of coal gasification, S. 1846. S. 1846 was introduced on May 12, 1971, with the objective of finding a method to meet this accelerated timetable for producing synthetic natural gas from coal in commercial quantities to meet our burgeoning energy requirements.

The bill and Department reports will be made part of the record at this point.

(The documents referred to follow:)

(1)

92D CONGRESS
1ST SESSION

S. 1846

IN THE SENATE OF THE UNITED STATES

MAY 12, 1971

Mr. JACKSON (for himself and Mr. Moss) introduced the following bill; which was read twice and referred to the Committee on Interior and Insular Affairs

A BILL

To establish a Coal Gasification Development Corporation, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*

3 That (a) the Congress recognizes that—

4 (1) natural gas is the least polluting of the fossil
5 fuels in that it causes no pollution from sulfur oxides and
6 particulate and emits the least amount of nitrogen oxides
7 per heat unit supplied;

8 (2) natural gas can be produced and transported
9 with less environmental degradation than the other fuels

1 and at costs that compare favorably with the competitive
2 fuels for uses where the various fuels are interchange-
3 able;

4 (3) for three consecutive years the amount of gas
5 consumed in the United States exceeded new supplies
6 found in the contiguous forty-eight States;

7 (4) projections of future gas demand are such that
8 every new supply source must be developed, including
9 natural gas by pipeline, importation of liquefied natural
10 gas from overseas sources, and the gasification of coal;

11 (5) gasification of coal has been tested on a small
12 scale in a variety of processes by a number of investiga-
13 tors, but to achieve commercial status for any of these
14 methods will require the construction and operation of
15 a large demonstration plant followed by the construc-
16 tion and operation of a commercial sized plant;

17 (6) it is important to provide the cleanest fuel to
18 the American consumer using resources that can be pro-
19 duced by American miners and which are secure from
20 the vagaries of foreign supplies; and

21 (7) the research and development effort is too large
22 for any single company to risk undertaking and a con-
23 sortium of companies would be difficult to assemble
24 without Federal leadership.

25 (b) It is therefore the policy of Federal Government to

1 bring this technology to commercial development as quickly
2 as possible by establishing a Government-industry program
3 jointly managed and funded to demonstrate commercial scale
4 methods of producing substitutes for natural gas.

5 SEC. 2. (a) There is hereby established the Coal
6 Gasification Development Corporation (hereinafter referred
7 to as the "Corporation"). The Corporation shall have a
8 Board of nine Directors consisting of individuals who are
9 citizens of the United States, of whom one shall be elected
10 annually by the Board to serve as Chairman. Five members
11 of the Board shall be appointed by the President of the
12 United States, by and with the advice and consent of the
13 Senate, and four members of the Board shall be appointed
14 by the President on the basis of recommendations received
15 by him from any private entity or entities entering into
16 contractual arrangements pursuant to subsection (d) of this
17 section. Pending the appointment of such Directors on the
18 basis of the aforementioned recommendations, three mem-
19 bers shall constitute a quorum for the purpose of conducting
20 the business of the Board. The President of the United
21 States shall call the first meeting of the Board of Directors.
22 Each Director of the Board not employed by the Federal
23 Government shall receive compensation at the rate of \$300
24 for each meeting of the Board he attends. In addition, each
25 Director shall be reimbursed for necessary travel and sub-

1 sistance expenses incurred in attending the meetings of the
2 Board.

3 (b) The Board of Directors is empowered to adopt and
4 amend bylaws, consistent with the provisions of this Act,
5 governing the operation of the Corporation.

6 (c) The Corporation shall have a President and such
7 other officers and employees as may be named and appointed
8 by the Board. The rates of compensation of all officers and
9 employees shall be fixed by the Board. No individual other
10 than a citizen of the United States may be an officer of the
11 Corporation.

12 (d) In order to assemble and organize industrial par-
13 ticipation in the carrying out of the purposes and functions
14 of the Corporation, the Administrator of General Services is
15 authorized to enter into contractual arrangements with any
16 private entity or entities under which such entity or entities
17 agree to participate in the carrying out of such purposes and
18 functions, including the furnishing of financial assistance in
19 connection therewith. Such contract or contracts shall
20 include such terms and conditions, consistent with this Act,
21 as the Administrator of General Services may prescribe.

22 SEC. 3. (a) It shall be the function of the Corporation
23 to select, on the basis of the best engineering information
24 available, the two most technically and economically feasible
25 methods for manufacturing substitute natural gas from coal.

1 After selection of such methods, the Corporation is author-
2 ized to design, construct, operate, and maintain a demon-
3 stration-type facility for each such method selected in order
4 to determine the technical and economical feasibility thereof.
5 If on the basis of the operation of each such demonstration
6 facility the Corporation determines that the method so dem-
7 onstrated is a technically and economically feasible method
8 for manufacturing substitute natural gas from coal on a
9 commercial scale, the Corporation is authorized to design,
10 construct, operate, and maintain, for each such method
11 demonstrated, a full-scale, commercial-size facility to manu-
12 facture substitute natural gas from coal by such method.

13 (b) Substitute natural gas produced by such commer-
14 cial facilities shall be disposed of in such manner and under
15 such terms and conditions as the Corporation shall prescribe.
16 The Corporation shall arrange to deliver any substitute nat-
17 ural gas so manufactured to such buyer as may be author-
18 ized, by contract or otherwise, by the Corporation. All
19 revenues received by the Corporation from the sale of such
20 gas shall be available to the Corporation for use by it in
21 defraying expenses incurred in connection with carrying out
22 its functions under this Act.

23 (c) The Corporation shall make available, by license
24 or otherwise, on a nonexclusive royalty free basis without ter-
25 ritorial limitation the use of any patent obtained by the

1 Corporation under any law of the United States or any
2 foreign country for or with respect to any invention made
3 in the performance of any activity conducted pursuant to
4 this Act. On and after the dissolution of the Corporation and
5 the transfer of its patent rights in accordance with section 6,
6 the Administrator of General Services shall administer such
7 patents rights in accordance with the provisions of this
8 subsection.

9 SEC. 4. In carrying out its functions under this Act, the
10 Corporation is authorized to enter into contracts, leases, or
11 other arrangements; to own, manage, operate or contract
12 for the operation of facilities authorized by this Act; to con-
13 duct research and development related to its mission; and
14 to acquire by construction or purchase, or to contract for the
15 use of, physical facilities, equipment, and devices which it
16 determines necessary in carrying out such functions. To
17 carry out its functions, the Corporation shall have, in addi-
18 tion to the powers conferred by this Act, the usual powers
19 conferred upon corporations by the District of Columbia
20 Business Corporation Act. Leases, contracts, and other ar-
21 rangements entered into by the Corporation, regardless of
22 the place where the same may be executed, shall be gov-
23 erned by the laws of the District of Columbia.

24 SEC. 5. The Corporation shall transmit to the President
25 of the United States and the Congress, annually, commenc-

1 ing one year from the date of the enactment of this Act,
2 and at such other times as it deems desirable, a comprehen-
3 sive and detailed report of its operations, activities, and
4 accomplishments under this Act, including a statement of
5 receipts and expenditures for the previous year. At the time
6 of its annual report, the Corporation shall submit such legis-
7 lative recommendations as it deems desirable, including the
8 amount of financial assistance needed for operations and for
9 capital improvements, the manner and form in which the
10 amount of such assistance should be computed, and the
11 sources from which such assistance should be derived. Such
12 report shall be available to the public.

13 (b) All reports, plans, specifications, cost and operat-
14 ing data of the corporation acquired by it in connection with
15 the carrying out of its duties under this Act, shall be made
16 available by the Corporation in accordance with the provi-
17 sions of section 552 of title 5 of the United States Code.

18 (c) The Corporation shall make annual reports available
19 to interested parties on the progress of its operations. Such
20 reports shall be in sufficient detail so that independent engi-
21 neering and economic judgments can be made based on such
22 reports. Detailed drawings and other information of value to
23 those who might be interested in commercial development
24 shall be placed on open file by the Corporation on a con-
25 tinuing basis for examination by interested parties.

1 SEC. 6. On or before the expiration of six years follow-
2 ing the date of the enactment of this Act, the Board of Di-
3 rectors shall take such action as may be necessary to dissolve
4 the Corporation. In carrying out such dissolution, the Board
5 of Directors is authorized to dispose of all physical facilities
6 of the Corporation in such manner and subject to such terms
7 and conditions as the Board determines are in the public
8 interest. All assets of the Corporation, including the proceeds
9 from the disposition of such facilities, on the date of its dis-
10 solution, after satisfaction of all its legal obligations, shall be
11 made available to the United States and deposited in the
12 United States Treasury as miscellaneous receipts. All patent
13 rights of the Corporation shall, on such date of dissolution, be
14 vested in the Administrator of General Services.

15 SEC. 7. (a) Each department, agency, and instrumental-
16 ity of the executive branch of the Government, including in-
17 dependent agencies, is authorized and directed to furnish to
18 the Corporation, upon its request, any information or other
19 data which the Corporation deems necessary to carry out its
20 duties under this Act.

21 (b) The Corporation is authorized to utilize, on a reim-
22 bursable basis, the services of any personnel made available
23 by any department, agency or instrumentality, including
24 any independent agency, of the Government.

1 (c) The Corporation may procure the services of
2 experts and consultants without regard to the provisions of
3 title 5, United States Code, governing appointments in the
4 competitive service, and may compensate such experts and
5 consultants without regard to the provisions of chapter 51
6 and subchapter III of chapter 53 of that title relating to
7 classification and General Schedule pay rates, in accordance
8 with section 3109 of that title.

9 SEC. 8. There are authorized to be appropriated to the
10 Corporation, for the fiscal year beginning July 1, 1971,
11 the sum of \$5,000,000, and for each of the next five
12 succeeding fiscal years, such sums as may be necessary.
13 All funds appropriated pursuant to this section shall remain
14 available until expended. Notwithstanding any other pro-
15 visions of this Act, in no case shall funds appropriated
16 pursuant to this section for any fiscal year be expended in
17 an amount in excess of 60 per centum of the costs to the
18 Corporation in connection with the carrying out of its
19 duties under this Act for that fiscal year.

U.S. DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C. July 23, 1971.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: There is pending before your Committee S. 1846, a bill "To establish a Coal Gasification Development Corporation, and for other purposes."

We recommend against enactment of this bill.

S. 1846 would make it the policy of the Federal Government to bring technology to commercial development as quickly as possible by establishing a government-industry program jointly managed and funded to demonstrate commercial scale methods of producing substitutes for natural gas. Specifically, the bill establishes the Coal Gasification Development Corporation whose principal function would be to select the two most feasible methods for manufacturing substitute natural gas from coal. The Corporation would be authorized to design, construct, operate and maintain a demonstration-type facility for each method selected in order to determine the technical and economic feasibility of each. S. 1846 further requires that the Corporation be dissolved 6 years after enactment of the bill, and authorizes the appropriation of \$5 million for the year beginning July 1, 1971, and such sums as may be necessary for the succeeding 5 years.

The Department of the Interior has had underway for several years a coordinated program involving research, design, construction and operation of several coal gasification prototype plants. The President's June 4 Clean Energy Message announced a major new initiative in coal gasification. This initiative will make it possible to expand the number of pilot plants, making it possible to test new methods more expeditiously so that we can soon select the appropriate technology for a large scale demonstration plant. Under this new initiative, Federal expenditures for a joint government-industry program would be expanded to \$20 million a year. Industry has agreed to provide \$10 million per year for this effort. We believe that the President's program should have the opportunity for going forward any consideration is given to an independent corporation to conduct the operation described in S. 1846.

The Interior Department has just completed an agreement with the industry on the management of this expanded joint program. In addition, we have requested the National Academy of Engineering to make an independent study of coal gasification technology. The Academy will advise us on the technological aspects of this program.

A new organization, such as that created under S. 1846, would bring confusion and delay to this carefully developed program. We believe that the most effective way of accomplishing our common goal of making coal gasification a commercial reality is to move ahead as rapidly as possible along the lines already established.

Finally, S. 1846 would be incompatible with the philosophy of the President's proposed reorganization of the Federal Government. The President's proposal would group most of the energy functions of the Federal Government into the Department of Natural Resources. We firmly believe that the planning and funding of energy research and development should be accomplished within an agency charged with the mission of insuring that the total energy resources of the Nation are effectively utilized.

The Office of Management and Budget has advised that there is no objection to the presentation of this report from the standpoint of the Administration's program.

Sincerely yours,

HOLLIS M. DOLE,
Assistant Secretary of the Interior.

EXECUTIVE OFFICE OF THE PRESIDENT,
OFFICE OF MANAGEMENT AND BUDGET,
Washington, D.C., July 26, 1971.

Hon. HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs, U.S. Senate, New Senate
Office Building, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in response to your request of July 2, 1971, for the views of the Office of Management and Budget on S. 1846, a bill "To establish a Coal Gasification Development Corporation, and for other purposes."

The Office of Management and Budget concurs in the views of the Department of the Interior and the Office of Science and Technology in their reports on S. 1846, and accordingly, recommends that the bill not be enacted.

Sincerely,

WILFRED H. ROMMEL,
Assistant Director for Legislative Reference.

EXECUTIVE OFFICE OF THE PRESIDENT,
OFFICE OF SCIENCE AND TECHNOLOGY,
Washington, D.C., July 26, 1971.

Hon. HENRY M. JACKSON,
*Chairman, Committee on Interior and Insular Affairs, U.S. Senate, Washing-
ton, D.C.*

DEAR MR. CHAIRMAN: Your letters of June 11, 1971, July 2, 1971 and July 15, 1971, requested that we provide the Committee with a written statement on S. 1846; a bill to establish a Coal Gasification Corporation. I am most pleased to respond.

The bill would establish a policy of developing the technology for producing substitutes for natural gas from coal through a jointly funded and managed government-industry program. To accomplish this objective the bill would establish a Coal Gasification Development Corporation whose function would be to select and demonstrate two coal gasification technologies. For each technology the corporation would build and operate a demonstration plant and subsequently a full-scale commercial plant. The corporation would have a life of six years and would obtain its funds from government and industry commencing with \$5 million in federal funds for fiscal year 1972.

The concept of converting the nation's vast reserves of coal to gaseous fuel is timely and important but it is not altogether a new idea. In many areas coal gas was used before natural gas became available even though it was product with lower Btu content and relatively expensive. After the Second World War this form of gas was displaced by natural gas transported in large diameter natural gas pipeline systems to consumers throughout the country. Natural gas is a high-Btu, relatively clean source of energy that became available at savings to consumers over competing sources. It now provides about one-third of all the nation's energy.

The rapid growth in natural gas consumption had been expected to taper off in the 1970's. But the urgent pressures for new supplies of clean fuels to meet our recently established air quality standards and the higher growth rates in energy use generally have resulted in a continued high demand for natural gas. The result has been a shortage of natural gas as compared to the potential demand. Our present supply of natural gas is limited by the available wells, pipeline and other facilities. We have not yet exhausted our natural gas resources, but future demands are so great in relation to potential supplies that the limited volumes of this resource available in the ground do not appear adequate to meet our future needs.

The President's June 4, 1971 message to the Congress on energy outlined the various federal efforts underway to augment gas supplies. The short term measures included accelerated leasing of federal lands to speed the discovery of new gas fields, actions by the Federal Power Commission to provide industry

with greater incentives to develop new supplies of natural gas and facilitating imports of gas.

The important point in the President's message with respect to gas supply is that over the longer term we must expand our supply of this relatively clean form of energy by the conversion of coal to high-Btu pipeline quality gas.

The development of coal gasification technology was singled out by the President as one of the three major technological initiatives in his message. We propose to develop a new technology to produce high quality gas at the coal mine which can then be transported inexpensively by our vast gas pipeline system. This technology is quite different from the old manufactured gas which is not compatible with natural gas transportation or use, and can only be produced and used locally at relatively high cost.

The President's energy message announced the initiation of a cooperative program with industry to expand the number of pilot plants in order to facilitate the selection of appropriate technology for a large scale demonstration. This decision was based on the realization that greater focus and urgency were required in order to make coal gasification a commercial reality as promptly as possible. A number of technical and economic hurdles remain. To overcome these an expansion of the current Interior pilot plant effort is required followed by the construction of a large scale demonstration plant.

During the pilot plant phase, which will require another three or four years, this program is planned to be funded at a level of \$30 million per year—\$20 million from the federal government and \$10 million from the American Gas Association and its members.

As we move into the demonstration phase the level of funding required will increase and so will the industry's share of the larger total since the effort will be nearer to commercialization. Based on continuing technical and economic success, we could expect that under the contemplated program a demonstration plant on the order of one-third the size of a full-scale commercial plant would be operational by 1980. Gas from coal could therefore be expected to have a significant impact on natural gas supplies during the latter part of the 1980's after a number of full size plants were in operation.

In reviewing S. 1486 the first point to be noted is that we are in close agreement with essentially all of the findings made in Section 1 thereof. The policy statement itself is fully consistent with the Administration policy announced in the President's energy message. S. 1846 seeks to accelerate the coal gasification research and development efforts through a high priority joint government-industry program. That is precisely the type of program initiated in the President's energy message. And an accelerated program is now underway in the existing organizations within the Interior Department working with industry.

We are currently seeking the higher level of federal funding from the Congress and the AGA is now security pledges from individual companies for its share of the \$30 million annual effort. We have every expectation that both the federal and industry funds will be forthcoming. And Interior will soon be completing arrangements for a joint management agreement to guide the research and development effort.

To provide technical assistance in the expansion of the program Interior has contracted with the National Academy of Engineering to establish an ad hoc panel which is currently evaluating coal gasification technology. The panel has already met with the developers of all of the major processes, and is now preparing their recommendations. Dr. Thomas H. Chilton is the Chairman of the group.

In view of these recent initiatives we believe that the most effective means of accomplishing our goal of making coal gasification a commercial reality is to move ahead as rapidly as possible along the lines already established.

The forming of a special corporation to deal only with coal gasification along the lines presented in S. 1846 is, of course, an alternative administrative mechanism that might have value in the absence of an ongoing joint effort between government and industry. But in the present circumstances it would not appear to be necessary since the President's energy message announced such a program. Shifting the new program to a new special corporation could in fact be expected to delay the new pilot plant work. In addition, the establishment of a special corporation for coal gasification would tend to establish a precedent for other ad hoc measures to deal with specific urgent energy problems. We doubt that further fragmentation of the responsibility for energy research and development is wise.

What is needed is to consolidate all of our important federal energy resource development programs within a new Department of Natural Resources. A pro-

posal for such a Department is now pending before the Congress as part of the President's government reorganization program. We believe that the planning and funding of energy research and development should be accomplished within such a Department charged with the mission of examining all of the possible options and insuring that the total energy resources of the nation are effectively utilized. The execution of these programs would be accomplished by those agencies and institutions most appropriate under the particular circumstances.

I believe we should also note that for several years we will still be building and operating pilot plants to determine which approaches are feasible to pursue to larger sizes. As we move toward the construction of a large coal gasification demonstration plants, special new institutions may well be required to construct and operate the facility. We would expect such arrangements to evolve out of the continuing cooperative program with the industry, however, rather than be prescribed at the outset.

In summary then we support the findings and policy stated in S. 1846 but do not believe the formation of a special coal gasification development corporation is necessary or warranted at this time. The cooperative government-industry program announced in the President's energy message is intended to accomplish this important policy goal as expeditiously as possible.

Sincerely,

EDWARD E. DAVID, Jr.,
Director.

Senator Moss. Hearings on S. 1846 were held on July 27 and 28, 1971. All of the witnesses who testified or submitted letters for the record were in agreement about the need for an accelerated coal gasification program as well as the findings in section 1 of the bill which outlines the reasons why such a bill was thought to be necessary.

The administration opposed the passage of the bill on the grounds that the President's program on energy gave a new initiative to coal gasification research and this should have an opportunity to go forward before any consideration was given to an independent corporation to carry out the provisions of S. 1846.

The President's program was jointly sponsored by industry, represented by the American Gas Association, and the Department of Interior, the first 4-years expenditures would be at the rate of \$30 million per year and the costs were to be shared by Government and industry. Industry will supply one-third of the total expenditures.

Several witnesses suggested that both the Department of Interior—American Gas Association program and the program called for by S. 1846 should be pursued.

Subsequent to the hearings a number of newspaper stories appeared that reported that a number of companies were planning to proceed with construction of full-scale gasification plants. These include:

(1) FMC Corp., (2) Texas Eastern Transmission Corp., (3) Utah International, Inc., (4) El Paso Natural Gas Co.

Some of these plants were reported to be planning to use coal and others are said to use petroleum products as the raw material from which to produce gas.

This hearing today is to obtain detailed information on the plans of the various companies with respect to commercial coal gasification plants, including their size, location, timing, availability of resources—coal and water—and environmental protection plans. Also to be determined are the types of process limitations, if any, and, to the extent possible, the anticipated costs of the synthetic gas.

In addition, the administration witnesses have been requested to develop answers to the following questions:

(1) Has the additional Federal funding called for in the President's energy message been requested: What state in the budget process has it reached?

(2) Has industry commitments for their share of the funds been received? Have the funds actually been made available to the department, and, if not, when will they be made available?

(3) What are the terms of the Government-industry cooperative agreement?

(4) Does the announcement of commercial-sized development change Interior's research plan and, if so, how, and if not, why not?

We have many distinguished witnesses here this morning, our colleague from West Virginia, the chairman of the Public Works Committee, Senator Randolph, has joined us and will be with us for a time at least this morning until his other commitments call him away, and I am pleased to recognize Senator Randolph and ask him if he has any remarks to make at this point.

STATEMENT OF HON. JENNINGS RANDOLPH, A U.S. SENATOR FROM
WEST VIRGINIA

Chairman RANDOLPH. Mr. Chairman and Senators Jordan and Hansen, our fuel shortages in World War II years made this Senator, then a Member of the House of Representatives, one of the pioneer advocates of using coal as a base for the development of synthetic liquid fuels and for the gasification of coal.

I joined with Senator Joseph O'Mahoney of Wyoming in authoring and introducing and pressing to passage the Randolph-O'Mahoney Synthetic Liquid Fuels Act which created a coal liquifaction and coal gasification research and development program during the late years of the Roosevelt administration and all of the Truman administration until abandoned during the early years of the first Eisenhower administration.

Then, in the creation and subsequent continuous authorization of the Office of Coal Research in the Department of the Interior at the end of the decade of the 1950's through the administration to date, research and development in coal liquid synthetics and gasification of coal were revived. I have been among those most active in supporting authorization of an appropriation for projects in this field and others in the Office of Coal Research.

Since the earliest inception of the Randolph-O'Mahoney measure in those fateful World War II years, I have continuously felt that the United States of America must have the capability to feasibly produce synthetic liquid fuels from coal and high quality clean-burning gas from coal. I believe so today—perhaps even more so than in yesteryear.

With a stronger-than-ever interest in the need to substantially reduce the pollution of the air we breathe and the water we use for human consumption and other purposes—and with the unquestioned need for larger and larger quantities of fuels and energy, especially the cleaner burning fuels and the cleaner produced energy, the need for greater than ever anticipated volumes of clean burning pipeline quality gas from coal becomes apparent. But we will still be a long time achieving this goal.

Meanwhile, available supplies of natural gas, especially domestic American natural gas within the confines of the first 48 States, are diminishing much too fast without adequate replacement at a time when this clean burning fuel is greatly needed.

So, with this history and these recognitions, I certainly urge very high priority attention by the Congress, by the executive branch, and by business and commerce to the development of gas from coal. And, in this urging, I express the belief that coal gasification efforts need not be and should not be devoted exclusively to the researching and developing of pipeline quality gas. On-site production of coal gas for the fueling of electric generating plants—at the site—is believed by a growing number of experts to have high potential for efficiency and feasibility from both the economic and technological standpoints.

And, Mr. Chairman, speaking of technological and economic feasibility, I feel it is appropriate to express a few words of caution, a form of caution which, however, I differentiate from pessimism.

My words of caution are these:

Even if coal gasification—pipeline quality or otherwise—should be researched and developed to full engineering and professional feasibility it could conceivably be prevented from being economically feasible due to inadequate production and/or outsized pricing of the coal which would be the feedstock for gasification.

This country may some day—which I hope will never come—have such a need for fuels and energy that price of the fuels, natural or synthetic, and cost of the energy would not be anything approaching the serious consideration that price is today.

Coal prices cannot go on and on shooting upward, and I have no doubt it is a fact that only increasing productivity for every dollar of capital, operating and maintenance investment in the coal mines will stabilize in any degree coal's price structure.

The country needs coal gasification. The air we breathe may need, sooner than we realize, the cleaner burning that gasified coal is said to be able to, or is capable of providing.

Operators and coal miners alike, and, indeed, the Congress of the United States too, have joint and substantial responsibilities to help stabilize the price of coal at a reasonable level. Some economists seem to believe that level already has been passed.

Frankly, I included the Congress in this declaration of joint responsibility because several recent Congresses have passed laws and taken actions which have added materially and, in fact, substantially, to the costs of producing coal. No doubt there is a strong feeling—as there was in the Congresses which passed the laws, that they were justified actions in the interest of humanity and, indeed, in the public interest. But we all must realize that there is a saturation point beyond which coal prices cannot go—relating to coal gasification—relating to the generation of electricity by coal-steam method—and, surely, relating to the survival of the coal industry itself.

Again, Mr. Chairman, I realize I have spoken too long, but I do appreciate your allowing me to have these remarks included at the outset of what I know will be a very informative record.

Senator Moss. Thank you very much, Senator Randolph. Your long leadership in this field of utilization of coal as a resource to supply energy and efforts to get liquification or gasification of coal underway is recognized.

You represent one of the most important States in the Union in the production of coal and therefore you have a long association and knowledge of coal production. So we heed your words and we are very pleased to have them on the record for the consideration of the fuel committee. We are grateful you have come this morning and we hope that you can remain with us, as long as you are able, until your other commitments call you away.

Do any of my other colleagues have any opening statements to make?

Senator HANSEN. No.

Senator JORDAN. No statement.

Senator Moss. All right, we will proceed then. The first administration witness is the Honorable Hollis M. Dole, Assistant Secretary for Mineral Resources. I don't know whether Secretary Dole thinks

we are honoring him or punishing him, this is his third appearance before this committee this week, and all on different bills we are considering.

I think we can say without any contradiction that he makes a great witness. He knows his business and he comes here and talks to us candidly and openly. We are delighted to have you back with us, Secretary Dole, this time to talk about S. 1846, and the position of your Department on developing coal gasification. We would like you to respond to the particular questions I mentioned in my opening statement, if you would, please.

STATEMENT OF HOLLIS M. DOLE, ASSISTANT SECRETARY FOR MINERAL RESOURCES, DEPARTMENT OF THE INTERIOR; ACCOMPANIED BY DR. LEROY FURLONG, GEORGE FUMICH, AND WILLIAM CRENTZ

Mr. DOLE. Mr. Chairman, thank you very much. I would like to bring with me to the witness table Mr. George Fumich, Director of our Office of Coal Research; Mr. William Crentz, who is Assistant Director for Energy within the Bureau of Mines; and Dr. Furlong who is my special assistant on science and technology.

Senator Moss. We would be happy to have all of those gentlemen join you at the witness table and be available for questions.

Mr. DOLE. I would like to compliment you and your committee for the promptness with which you have begun this hearing and for the great interest that all of the members of your committee have shown, plus Senator Randolph and his deep interest in energy. I think this is a real compliment to the administration that you would be so interested in this very difficult problem that we have right now, and that is energy.

I would like to say good morning to my Senator from Oregon, Senator Hatfield.

Senator HATFIELD. Good morning.

Senator Moss. You may proceed, Mr. Secretary. We are pleased to have you here. We do indeed have a problem to address ourselves to, and we are looking forward to your help.

Mr. DOLE. Mr. Chairman and members of the Senate Committee on Interior and Insular Affairs, I am happy to appear before you to testify on those matters affecting coal gasification, outlined in your letters of October 14 and November 3, 1971, to Secretary Morton. In the 4 months since this committee held hearings on S. 1846, a bill to establish a coal gasification corporation, several private firms have announced their intentions to initiate gasification projects.

The committee is also well aware of the Nation's declining ability to supply future natural gas requirements, and we will not burden you with statistics or projections. It is worth emphasizing, however, that a serious gas shortage is with us today. The problems manifest themselves in various ways: No additional gas for existing customers, waiting lists of new customers, and increasing curtailments of gas to industry. Reports of these actions are on an individual basis, but collectively represent a national problem of growing importance.

Industry actions to supply the required amounts of gas have fallen behind need. These actions, however, provide a rational framework for assessing current events in relation to Interior's coal gasification program.

The pattern of industrial actions actually began a number of years ago. Technology was available to make importation of natural gas in liquefied form a feasible option. Currently, constrained principally by available transportation, LNG imports may play an increasingly important role in our future energy picture.

The production of synthetic pipeline gas from petroleum forms is another available option. Some companies, such as Texas Eastern Transmission Corp., Consolidated Natural Gas Service Co., Consumers Power Co., Algonquin National Gas, and Brooklyn Union Gas, appear to have firm plans for the gasification of naphtha, while Columbia Gas Systems is planning to gasify LPG. The plan of at least four other companies for gasifying naphtha, LPG, or crude oil appear to be in various stages of development.

Another apparent option currently making headlines is the announcement by some industrial firms of plans concerning coal gasification. For example, the El Paso Natural Gas Co. is reportedly hoping to have a coal gasification plant on the Lurgi process in operation by 1976. Furthermore, Texas Eastern Transmission Corp. and Pacific Lighting Service Co., with Utah International, Inc., as their coal supplier, have announced an ongoing economic feasibility study for deriving synthetic pipeline gas from coal by the Lurgi process. Although the Lurgi gasification process is commercially available, there are certain characteristics of this technology, as I shall point out later, that are not conducive to producing an early, large, low-cost supply of supplemental gas.

We believe that the options just discussed do not provide the basis for a long-term solution to our increasing demands for gaseous fuels. Such a solution must be based on more efficient coal conversion processes that will lower manufacturing costs.

Toward that goal, the Government, on August 3, 1971, acting through the Department of the Interior, entered into a cooperative agreement with the American Gas Association to develop coal gasification processes. The plan is to develop a joint Government-industry effort to establish a coal gasification industry which can serve a vital role in helping to solve the energy and pollution problems facing the Nation today. This can be accomplished by taking advantage of our greatest known natural resource, coal, by converting it to clean-burning gas for distribution in our existing networks of transmission and distribution lines.

The first 4 years of this program are aimed at obtaining firm data so that engineering for a demonstration plant can be undertaken by the mid-1970's. With an allowance for completion of engineering and construction, a commercial-scale plant would be available for operation late in this decade. The research and development program will accelerate the development through the pilot plant stage of coal gasification methods presently under active study by OCR, and will culminate with the construction and operation of a technically feasible

demonstration plant in the shortest possible time. The best process may prove to be one presently under development, but it is more likely that it will consist of an optimum selection from various process elements developed at the pilot plants included in the program.

The proposed program will have as a base three coal gasification projects under contract by the Office of Coal Research. The most advanced project is the Hygas project in Chicago, Ill. The research is being carried out by the Institute of Gas Technology, and the American Gas Association has been partially funding the project for several years. The second project is the CO₂ Acceptor process for which a pilot plant is being completed in Rapid City, S. Dak. Shake-down operations should begin in the spring, and plant operations later in the year. Integrated operation is projected for next summer. The third major project is being researched by Bituminous Coal Research, Inc., a research subsidiary of the National Coal Association. It is called the Bi-Gas process. This work has been carried on in Monroeville, Pa., and construction of a pilot plant is planned for Homer City, Pa.

All of these plants will include provisions for studying the various coal gasification steps, which are: 1. Pretreatment—when needed. 2. Coal feed and discharge systems. 3. Gasification. 4. Gas cleanup. 5. Methanation.

Other elements necessary to build a complete plant, such as coal preparation, coal handling, compressors, et cetera, do not require development work and can be engineered and purchased.

The processes being investigated differ with respect to the method of gas-solid contacting, supply of heat to the steam decomposition reaction, the gas cleanup method, and methanation system. A broad technical base has been established to proceed with the accelerated program. Administrative procedures have been established to obtain maximum results with minimum cost. Good results can be exploited and unfruitful investigations will be dropped without delay. This will eliminate duplication and minimize development time.

As I mentioned earlier, the goal is to establish the best process elements for a demonstration plant in 4 years. The exact size of this unit has not yet been decided, but would probably handle about 5,000 tons per day of coal, and produce about 80 million standard cubic feet per day of pipeline quality gas, gas having a minimum thermal value of 950 B.t.u. per cubic foot.

Upon successful completion of the pilot plant stage leading to a demonstration plant, it is obvious that this Government research will have a rapid payout as noted by the interest expressed earlier. We are fortunate in having a vigorous gas industry which will raise the necessary venture capital to insure construction of the plants. Commercial coal gasification will move forward very rapidly in the 1980's, with many attendant side benefits. The funds expended to develop the technology will be returned manifold in the form of taxes.

Jobs will be created in many previously rural areas of the country, since each commercial scale coal gasification plant can be expected to create some 1,200 to 1,800 new jobs. Having a firm supply of gas will allow our pipeline and distribution companies to service thousands of small-scale industries and businesses that need gas for commercial

development, but cannot obtain it in a period of short supply. Commercial coal gasification plants will also reduce our dependence on foreign sources for something as basic as natural gas.

I shall now state and reply to the specific questions raised by the committee:

One, has the additional Federal funding called for in the President's energy message been requested? What stage of the budget process has it reached?

The Department has requested a supplemental appropriation of \$10,280,000 for fiscal year 1972. The Director of the Office of Coal Research has testified in support of the supplemental request during the past month. The Appropriations Committees of the Congress are considering the request.

Two, have industry commitments for their share of the funds been received? Have the funds actually been made available to the Department: If not, when will they be?

The American Gas Association has secured firm commitments from its members for essentially all of its \$10 million share of the program. The AGA contribution will become available to the Department as soon as we have our share of the required funding.

Three, what are the terms of the Government-industry cooperative agreement?

At this time I would like to submit for the record a copy of the agreement between the Department of the Interior and the American Gas Association.

Senator Moss. Thank you, and that will be printed in the record. (The document referred to is in the appendix.)

Mr. DOLE. This document sets forth the operating organization including the steering committee, consisting of the Assistant Secretary—mineral resources, the president of the National Academy of Engineering, and the president of the American Gas Association; the program directors; the operating committee; and four advisory groups. In addition there are articles concerned with contracts, the funding of contract costs, patents, data, and termination of the agreement.

Four, does the announcement of commercial-sized development change Interior research plans? If so, how? If not, why?

The announcement of commercial-sized development does not change Interior research plans. As a matter of fact, we feel that this tremendous interest in coal gasification lends impetus to our getting on with the job of perfecting coal gasification technology. It should prove encouraging to Congress to know that the expenditure of research funds which they may authorize will result in immediate utilization.

In the case of those companies that announced plans to gasify coal such as El Paso Natural Gas or the consortium of Texas Eastern Transmission Corp., Pacific Lighting Service Co., and Utah International, Inc.—the coal supplier for Texas Eastern and Pacific Lighting—the commercially available Lurgi gasification process is reportedly planned for use. The Lurgi process produces gas having a thermal value of 450–500 B.t.u. per cubic foot. Furthermore, this fixed bed process has low through-put characteristics; the process has not yet been proved adequate for caking coals; and the methanation stage, following coal gasification and cleanup, is still under research.

It is worthy of note that El Paso, Texas Eastern, and Pacific Lighting are all participants in the Interior-AGA gasification program. In addition, it is significant that the announcements by these companies did not come out until after the President's Clean Energy Message of June 4, 1971.

The FMC Corp. contemplates coal as feed for its COGAS process, based on the COED process pilot plant developed under the sponsorship of the Office of Coal Research. The company reportedly has stated that the selection of optimum process conditions for char-gasification and the methanation steps are the major problems. This is another case in which major research will probably have to be undertaken.

In the case of those companies that do not contemplate coal but rather naphtha, crude oil, or LPG as the feed for their gasification systems there is the fundamental difference between the Interior-AGA program and theirs that our program is based on using the Nation's most abundant fossil fuel, coal. It is reasonable to expect that gas derived from petroleum will be higher priced, there will be a certain degree of dependence on foreign supplies, and the availability of raw materials will be limited.

We certainly hope for the success of these efforts because the demand for gas is very great. However, we believe that the most effective solution to supplementing our supply of natural gas lies in:

One, the gasification of the Nation's most abundant fossil fuel—coal.

Two, the development of improved technology that will produce synthetic pipeline gas from coal at the lowest possible cost.

We are aware of the technological difficulties involved in providing the people with a secure, clean gaseous fuel. However, we believe that these difficulties can be overcome and that our program has the greatest potential for assuring the earliest, least costly, and most reliable supply of synthetic pipeline gas.

That concludes my formal statement, Mr. Chairman. We would be pleased to respond to questions from your committee.

Senator Moss. Thank you, Mr. Secretary. That is a good report, and an optimistic one in the sense that it is obvious that you are moving right along in the effort to get a program underway. I am pleased to know that the budget request has been made and it is now before the Appropriations Committee in the supplemental appropriations bill. I assure you that members of this committee will do everything they can to see that the request is granted, because of the urgency in meeting our energy needs.

The request before the Appropriations Committee now is for \$10 million. Do you have a statement of the total cost of the 4-year program?

Mr. DOLE. Mr. Chairman, the total cost of the 4-year program is based upon \$20 million from the Government, plus \$10 million or 50 percent of this from private industry. This would figure out to \$30 million or 4 times 30, \$120 million. Hopefully we can be successful before this time, but just the mere element of time of construction and going through the pilot plant operations might take longer, but then again it could come to an early conclusion and it may not cost this amount of money. This is a statement, Mr. Chairman, based upon how we feel technology will develop.

Senator Moss. Will the Government participate in the demonstration plant when it operates?

Mr. DOLE. I think that was best answered in the President's Clean Energy Message of June 4, 1971, in which he says, and I quote from page 5.

We are determined to provide greater focus and urgency to this effort. We have, therefore, initiated a cooperative program with industry to expand the number of pilot plants making it possible to test new methods more expeditiously so that the appropriate technology can soon be selected for a large-scale demonstration plant. The Federal expenditure for this cooperative program will be expanded to \$20 million a year. Industry has agreed to provide \$10 million a year for this effort. In general we expect that the government will continue to finance the larger share of pilot plants and that industry will finance the larger share of the demonstration plants.

So, as brought out in the President's message, Mr. Chairman, it is determined that in the very high risk area, that is of developing the process at the pilot plant stage, it would be in the best interest of the people of the United States that the Government do this. Then when we go to the demonstration scale plant, which still has a high element of risk, but not nearly as high, that the industry, those who are concerned about supplying an adequate natural gas base to our country, should take the bulk of the cost.

Senator Moss. The gas that is produced in the demonstration plant I suppose would be disposed of in the ordinary channels of distribution. Would the consortium benefit by that in proportion? That is, would the Federal Government get any repayment for its money out of gas that is produced in demonstration?

Mr. DOLE. I would imagine, Mr. Chairman, that the amount of gas that would be produced at either the pilot plant stage or the demonstration stage would not be very large and whether or not that would be put directly into the system or in some other way disposed of, I don't know at this time. I will tell you this, we do not know whether this will be partially returned to the Government at this time.

Senator Moss. That hasn't been negotiated?

Mr. DOLE. No, sir.

Senator Moss. I understand from your testimony that this development work is directed toward production of a high B.t.u. gas, the kind that is called pipeline gas. Has any consideration been given to a low B.t.u. gas program that might be applicable to advanced power generating systems?

Mr. DOLE. Yes, Mr. Chairman. We have asked the National Academy of Engineers not only to review our program to help us and guide us and aid us in the selection of the type of pilot plants for high B.t.u. gas that we should engage in, but we have also asked them to advise us concerning those plants that would end up in gas from coal being allocated directly to a systems plant for the generation of electric power.

At the present time we do not have any low B.t.u. plants on our drawing board in the Interior-AGA program. However, we are definitely looking into this.

Senator Moss. If we assume that within the 4-year span that you can have a successful demonstration plant operating and the process therefor developed that makes this gasification of coal economical, what rate then would you anticipate we would have to add additional

plants in order to close this gap of supply and demand which is now already upon us and is going to grow more acute?

Mr. DOLE. Mr. Chairman, in answer to that question, I think that we have to realize that the bulk of the gas that will be produced and supplied to the customers of the United States for our economical development will still have to depend upon natural gas.

What we are talking about are supplemental sources of gas. Now, we have, through the President's Clean Energy Message and through his recognition of problems that we are facing now as far as supplying energy to our Nation, embarked upon several things that are taken into consideration here. One is an accelerated leasing of offshore lands, outer Continental Shelf lands. These lands provide the best chance of early discovery of natural gas and the quickest time in bringing it onshore. We have the coal gasification program which will probably come in sometime in the 1980's. It is doubtful, even at the most optimistic, that by 1985 coal gasification will be furnishing more than just a percentage or two of our total gas requirements.

Industry is turning also to what I consider necessary supplemental but less secure sources of gas such as gas manufactured from naphtha, from LPG and imported LNG. I have noted here for the committee a map showing the tremendous pipeline network of the gas companies and they involve about 200,000 miles of pipeline, which is more than the amount of railroad lines that we have and the locations of these plants.

The gasification plant in the Four Corners area of Utah, Colorado, Arizona, and New Mexico is that of El Paso Natural Gas, the red dot, and is the only coal gasification plant. The two in the Great Lakes area gasify LPG imported from Canada, the one in the Chicago area gasifies naphtha and then you can see the collection of naphtha plants along the east coast.

Now, as you know, region one, the east coast area, is dependent very largely upon imported residual fuel oil. About 30 percent of their power is generated from the oil imported from overseas. For New England alone, this dependency for power generation upon oil exceeds 70 percent. It appears to me, Mr. Chairman, that reliance on importation of LNG and naphtha would place the eastern area in greater and greater jeopardy as regards secure sources of supply. Therefore, I think it is incumbent upon us to go forward with this coal gasification program as fast as we can.

Senator Moss. There isn't a coal gasification plant planned anywhere in the Appalachian region?

Mr. DOLE. There have been three announcements of coal gasification plants. As I brought forth in my testimony I think it is significant that these announcements came after the President's clean energy program. I think it is also significant that these people are interested in taking advantage of the technology that will be developed from our coal gasification effort. Consequently, I would say that these companies are doing a great service to their customers and the people of the country in announcing that they are going ahead with it.

I would imagine there would be a great many other coal gasification plants established as we proceed with our research.

Senator Moss. Senator Anderson, do you have any questions?

Senator ANDERSON. No questions.

Senator MOSS. Senator Jordan.

Senator JORDAN. Thank you, Mr. Chairman. Mr. Secretary, back last July the administration indicated that they opposed S. 1846. Is this still the position of the administration?

Mr. DOLE. Yes, Senator Jordan. We feel that although the coal gasification development corporation suggested by Senator Jackson is a fine idea and we welcome it, we feel that this program that we are embarked upon now should be given a chance. Moreover, we do not feel that the corporation concept is in line with the national mining and minerals policy act passed by Congress last year in which greater development by private enterprise is encouraged and we feel, furthermore, that this runs counter to the President's proposal for the reorganization of Government and the centralization within the proposed Department of Natural Resources of an energy and minerals area.

Senator JORDAN. You think then, the two proposals conflict with each other rather than complement each other?

Mr. DOLE. I think, Senator, they complement each other in that there is a recognition on the part of Congress and on the part of the administration of the need for attacking what is considered a real energy problem.

In essence, however, I believe they do conflict.

Senator JORDAN. In what way would the provisions of S. 1846 be a hindrance to the administration's proposal?

Mr. DOLE. In the first place, it established a corporation which reports directly to the President and the Congress and is not within the so-called Department of Natural Resources concept.

In another area, their handling of patents is in conflict with the recent administration announcement on the handling of patents. We do not feel that the funding it has mentioned in here is adequate.

There are other items in it, covered in our message that we submitted to the committee on a two-page transmittal, in the third and fourth paragraphs—I would be glad to read those into the record now, if you wish.

Senator JORDAN. I wish you would. I think it is important because I am sure we all want to achieve the same goal. No one wants to do away with any ongoing program, or to eliminate from consideration any ancillary program that might be able to contribute to the common pollution problem, but there is no need of duplication if it appears to exist, and there is no need of wasting money if that appears to be the case. So I wish you would develop it.

Mr. DOLE. Yes. We have reported this fall that—

The Department of the Interior has had underway for several years a coordinated program involving research, design, construction and operation of several coal gasification prototype plants. The President's June 4 Clean Energy Message announced a major new initiative in coal gasification. This initiative will make it possible to expand the number of pilot plants, making it possible to test new methods more expeditiously so that we can soon select the appropriate technology for a large scale demonstration plant. Under this new initiative, federal expenditures for a joint government-industry program would be expanded to \$20 million a year. Industry has agreed to provide \$10 million per year for this effort. We believe that the President's program should have the opportunity for going forward before any consideration is given to an independent corporation to conduct the operation described in S. 1846.

The Interior Department has just completed an agreement with the industry on the management of this expanded joint program. In addition, we have requested the National Academy of Engineering to make an independent study of coal gasification technology. The Academy will advise us on the technological aspects of this program.

A new organization, such as that created under S. 1846, would bring confusion and delay to this carefully developed program. We believe that the most effective way of accomplishing our common goal of making coal gasification a commercial reality is to move ahead as rapidly as possible along the lines already established.

Finally, S. 1846 would be incompatible with the philosophy of the President's proposed reorganization of the Federal Government. The President's proposal would group most of the energy functions of the Federal Government into the Department of Natural Resources. We firmly believe that the planning and funding of energy research and development should be accomplished within an agency charged with the mission of insuring that the total energy resources of the nation are effectively utilized.

Senator JORDAN. All right. Thank you. That was issued in July and it is still the position of the Department?

Mr. DOLE. Yes.

Senator JORDAN. Thank you.

Senator MOSS. Senator Hansen.

Senator HANSEN. Mr. Secretary, I want to compliment you on a very lucid and clear statement. I want to be certain I understood you correctly.

You spoke about the energy shortage in this country and although you praised the coal gasification effort, I understood you to say that in the immediate future we can't hope to bring this program into full fruition so as to obviate an energy crunch in this country.

Did I understand you correctly on that?

Mr. DOLE. Senator, you are absolutely right. As you well know, we are now in a position where we are virtually in irons. We have a problem. We are to have to depend more and more upon overseas sources of energy. This will be in the form of oil. What we are embarking upon right now is the planning that is required and the planning that probably should have been done 10 years ago, that will assure us that by 1980—and there into the future that this country will have sufficient energy resources that it can fuel the industries of this Nation in the way it should be.

Senator HANSEN. Did you say that you thought in the years just immediately ahead of us that the only way we can take care of the great and growing demand for this type of energy, natural gas or synthetic gas, would be either through the development of more drilled wells that would be gas producers or the importation of this source of energy?

Mr. DOLE. Right now in our energy mix 35 percent of it comes from gas, about 34 percent or roughly 75 percent from oil, around 20 percent from coal, around 4 to 5 percent hydro, and less than 1 percent from nuclear power.

Right now we are in the position where, because we are going to meet our clean air standards, we are going away from our high sulfur coals which are very prevalent in the Appalachian area and form the basic fuels for many of our generating plants. We do not have sufficient gas. Last year we used around 25 trillion cubic feet and found around 18 trillion cubic feet. Our discovery rate has not been meeting the demands of our utilization rate for some years.

So we have to turn to oil for that. In our nuclear areas we are being held up on that due to environmental considerations and, once again we have to turn to oil. We have reached the position here in the United States where we do not have any surplus capacity of oil.

Therefore, in order to meet these essential energy needs, we have no choice but to turn to overseas sources. Now, to remedy this we are accelerating our offshore leasing in the gulf coast of the United States, in the hopes that this will bring oil and gas to the shoreline within 3 to 5 years.

Our coal gasification, if we can get this program going, we can start furnishing more gas from indigenous source by 1980, 1985.

Our oil shale program, we are going forward with. If it is successful, perhaps we can be furnishing supplemental sources of oil from there in the period 1980-85. The liquid breeder reactor which is our hope in the nuclear area will not be before the 1980's, the burning reactor is in poor condition as is our supply of oil and gas.

So right now we are, as I mentioned, virtually in irons as to our energy situation and we must, whether we like it or not, depend upon overseas sources.

Senator HANSEN. Thank you, Mr. Chairman.

Senator MOSS. Senator FANNIN.

Senator FANNIN. Thank you, Mr. Chairman. Mr. Secretary, I commend you for your dedication to this program, for the great efforts that are being made to solve these problems. When we talk about coal gasification, of course, we are always thinking about the economics of it. What percentage of energy is used for on site power equipment or for the gasification of that sample coal to be used for that purpose in another location?

Mr. DOLE. Right now in a regular steam plant, the greatest efficiency is about 36 to 40 percent. I think the industry averages out around 38 percent.

In the conversion of coal gas, we estimate an efficiency of 60 to 70 percent.

Now, as noted all along, substitute natural gas is supplementary to natural gas. To use natural gas or its substitute in a powerplant would appear to be an inefficient use of the resource. However, this is what the chairman was referring to a little bit earlier in speaking of utilizing low B.t.u. gas from the Lurgi process, and developing a system in which low B.t.u. gas is derived from coal, cleaned up, and fed to an advance power cycle to generate electric power.

As to that efficiency, Mr. Crentz, would you care to comment on that?

Mr. CRENTZ. The process of deriving low B.t.u. gas from coal has an efficiency of perhaps 80 percent. Low B.t.u. gas cannot be shipped great distances, unlike pipeline quality gas. If you are using air instead of oxygen the thermal value of the gas may be even as low as 175 B.t.u. per cubic foot. The problem there is mainly one of removing particulates and other impurities at high temperature because it isn't efficient to decrease the temperature in order to achieve the clean up. You will want to use it hot. This does require some improved technology.

Senator FANNIN. That is what I am wondering about. I just can't visualize the utilization of gas, you are talking about 450 B.t.u. gas. You couldn't put it into pipeline gas unless we had some new method.

Mr. DOLE. No, sir. The lower B.t.u. gas would not work in household burners and furnaces. One of the big problems in the technology and development of coal gasification is the methanation of the gas to increase the thermal value to 900 or 1,000 B.t.u. per cubic foot.

Senator FANNIN. When you are talking about LPG, you are talking about propane or butane or the lower hydrocarbon gases?

Mr. DOLE. We are talking about a range of light hydrocarbons.

Senator FANNIN. Hydrocarbons have a lower pressure than butane?

Mr. DOLE. Butane or propane would be part of LPG. Mr. Ellerbrake from our Office of Oil and Gas is here and perhaps he could speak on that.

Senator FANNIN. Well, you take propane or butane, they are already gaseous materials and I just wondered what you mean by gasifying LPG?

Mr. ELLERBRAKE. They are liquified gases, liquid at lower temperatures.

Senator FANNIN. Well, gasified is anything above 44 below zero?

Mr. ELLERBRAKE. It could be used like LPG is now and allowed to burn that way.

Senator FANNIN. You would come out with the higher B.t.u. gas?

Mr. ELLERBRAKE. Yes.

Senator FANNIN. I didn't know that could be done, is this some recent development?

Mr. DOLE. No, sir, Senator Fannin; it is a technology that has been generally known for some time but as you know the hydrocarbons chains by various techniques can be converted into many different forms. This is why oil and gas are such valuable and very important forms of energy.

Senator FANNIN. I realize that. I remember when I was in the gas business we were trying to switch over like in small communities where you would have a shortage of natural gas, maybe during the winter time, and be able to give them a boost. We just couldn't find any way to convert that propane fuel into a usable gas. I didn't know they had a process for that.

Mr. DOLE. Yes; apparently they have developed this technology in the conversion of the LPG's to methane and therefore put the methane into the pipeline for use in the household.

Senator FANNIN. I notice El Paso Natural and other corporations now bring in liquified natural gas. Evidently the economics there would be an advantage over bringing in just propane and butane where it can be handled much easier.

Mr. DOLE. I have a hunch that not only economics involved here, but also the availability of material. For instance, in Algeria right now they are flaring a large portion of their gas. This is also true in many of the other Arabian and Middle Eastern areas where there is no large industrial market, so in the production of the oil they flare the byproduct gas. Now they are going to collect this, liquefy it, ship it, gasify it upon reaching port and put it in the pipeline.

Senator FANNIN. I am very pleased to have this information because I was wondering how the company can afford to have the equipment

that is most expensive available for that transportation. But that explains it.

Mr. DOLE. Now, when it comes to cost, remember we are paying for natural gas down in the fields of Oklahoma and Texas and the other areas where it is produced somewhere from 16 cents to 26 cents per Mcf. Now, as far as LNG is concerned, I have a statement here that El Paso gas, we would estimate the cost of LNG on the east coast to be per million B.t.u. around 70 cents for liquid and 75 cents for vaporized. Texas Eastern estimated it would be 81 cents with 5 cents for vaporizing. So what we are talking about here in coal gasification, in the conversion of naphtha to methane, and in the utilization of LNG and LPG are supplemental sources of gas in order to bring up our gas supply which is in such dire straits.

Senator MOSS. Senator Randolph had one question.

Senator RANDOLPH. Well, Senator Hatfield.

Senator MOSS. Well, I am going to come to Senator Hatfield because he is the witness' Senator. I thought if you had one question you could be on your way to answer the bell.

Senator RANDOLPH. Thank you, Mr. Chairman, I do find it necessary to leave. I listened as closely as I could with some interruptions to the testimony. I noticed in your statement, you were talking about the American Gas Association agreement to develop coal gasification processes. Am I correct in the understanding that the emphasis on that effort is to produce pipeline-quality synthetic gas?

Mr. DOLE. Yes, the 950 B.t.u. gas.

Senator RANDOLPH. The reason I asked that question, and I knew what your answer would be, is because of the research development efforts being conducted by the Environmental Protection Agency on combined power cycles for electric generation systems. The systems, as you know, combine coal gasification with a gas turbine generator at a single site.

It is my understanding, Mr. Chairman, that hearings are going to be held as a part of the energy study by the Interior and Insular Affairs Committee to explore the technology of the combined cycle. This will be done next year; is that correct?

Senator MOSS. That is correct; that will be part of our study.

Senator RANDOLPH. This leads me now to these two quick questions, Mr. Secretary. To what extent are these two Federal programs complementary?

Mr. DOLE. Senator Randolph, that is a very good question.

Senator RANDOLPH. I will ask the other question at the same time. To what extent is your agency coordinating your effort with the program of the Environmental Protection Agency?

Mr. DOLE. To answer your first question, the pipeline-quality gas is being developed for the consumer so that the consumer in his kitchen, in his furnace, in his air-conditioner will have material that can be transferred over the pipeline to assure him he will have adequate supplies. As far as the advanced cycles go and the effort within EPA, I met with Dr. Greenfield of EPA over 2 months ago and our staffs have been working in conjunction with each other to determine just how we can more efficiently go about this. We have some problems

within the executive branch of jurisdiction, just like you folks here in Congress do, and I will be the first to tell you that these have not been worked out at present, but we are still working on them.

Senator RANDOLPH. All right. Well, Mr. Chairman, I appreciate this assurance from the Secretary because I do think that now that with the environmental impacts being experienced now that we must continue to have coal research programs which emphasize environmentally clean fuels. May I say George Fumich here is a West Virginian and I hope you won't misunderstand when I say the work he does indicates his knowledge. But all of these programs can be coordinated and worked effectively?

Mr. DOLE. First, I would like to compliment Senator Randolph for his very deep interest in energy. I know of the efforts he made many years ago to get an energy study within the Congress and the support he has given your committee on this energy study, and I do appreciate the work and concern that you have in energy.

Now, as far as trying to work these together, yes, we are trying our best and hopefully they will come out all right. I suspect they will be but I am sure there will be blood let before it is over.

Senator RANDOLPH. Well, I compliment you, Secretary Dole.

(Correspondence and material submitted by Senator Randolph appear in the appendix.)

Mr. DOLE. Thank you.

Senator MOSS. That is the beginning of the vote. We will ask you then if you will remain, Mr. Secretary, we haven't finished our questioning. Senator Anderson still has a question he wants to ask, and Senator Hatfield has a question.

Mr. DOLE. I will be delighted to.

Senator MOSS. We will take a 10-minute recess to get our votes in and we will be back.

[Recess.]

Senator MOSS. We are back in session. We appreciate your waiting, Mr. Secretary.

Senator Hatfield, will you proceed with any questions you may have?

Senator HATFIELD. Thank you very much, Mr. Chairman.

I would like the record to show that the Secretary has certainly acquitted himself very well today, which is no surprise, since he comes from Oregon.

I would like to say to the chairman and to my colleagues that Mr. Dole was the State geologist and director of the minerals industries. He demonstrated his great capacity to reconcile differences of viewpoints and we established for the first time rules and regulations governing offshore rules and regulations for the State of Oregon. This was done in relationship with ecologists, fisheries, other interested parties along with the oil industry. It was one of the most remarkable achievements, I think, in light of oftentimes the opposite of irreconcilable forces, polarization of such areas.

Also, I might add that had such rules and regulations been adopted as the State of Oregon which permitted such exploration to go forward been invoked in the State of California, we would not have had the Santa Barbara disaster which occurred there.

I have a number of questions I would like to ask the Secretary.

First of all, if he would recall for me the figure that he gave on

the dependency of east coast energy? That is, I presume you are talking about generators. We are talking about electrical energy, the percentage of dependency on oversea shipments of oil or imported oil, is about 30 percent, and about 70 percent for New England alone.

Mr. DOLE. Ninety-four percent, Senator Hatfield, yes.

Senator HATFIELD. Of the electrical energy produced on the eastern seaboard?

Mr. DOLE. That is correct.

Senator HATFIELD. Depending on the import of oil to produce 30 percent of their electric energy?

Mr. DOLE. Yes, and I think it is around 8 percent of total east coast oil imports that comes from the Middle East. This figure will probably increase several-fold by 1985. If we get oil from Alaska by 1985, our total U.S. dependency on oversea sources of oil, which now are at a rate around 23 percent, will go up to around 38 percent. If we do not get this oil from Alaska, it will go up to somewhere around 45 percent dependency of the total United States on foreign energy supply.

Senator HATFIELD. What is the total dependency of the United States now on imports?

Mr. DOLE. Around 23 percent, Senator.

Senator HATFIELD. And that will go up with Alaska.

This is really the question I was getting to: What impact will the Alaska oil pipeline have on this import dependency? Can you give those figures again, please?

Mr. DOLE. Yes. If we get oil from Alaska by 1975 at the rate of 500,000 barrels a day into the West Coast, and that is increased to around 1 million barrels a day by 1980, and as much as 3 million barrels a day by 1985, our dependency upon overseas sources of energy supply will be around 34 percent, 34 to 38 percent, in that range.

If we don't get it, it is going to be up in the range of around 45 percent.

Senator HATFIELD. Thank you.

Now, Mr. Secretary, this whole question of energy is dependent or related to demand, and the demand is intimately related to technology. My question to you is: What is the department doing to make recommendations or to outline material upon which judgments and decisions can be made, as it relates to our choices in this matter of increased energy consumption?

For instance, we know that, according to some studies that have been made, that it takes five times more energy to produce throwaway beer bottles than returnable bottles; that it requires six times more energy to deliver freight by truck than by rail. Now, this is all part of the demand for power upon our total energy requirements of this country.

So, consequently, are we going pellmell down a road that is still presenting us with choices but failing to recognize those choices which include judgments and which include priorities and so forth and so on?

I am concerned that it appears to me that we are just accepting the present increasing rates of energy in this country without making such choices or without even considering the possibility of such choices.

Now, I know that many of these choices are intimately tied in with increased profits. We don't need detergents today as it relates to the ecological problems. Soaps provide us with all of these needs up to World War II, but we happen to know where soaps produced only 30

percent of profits that detergents are producing 52 percent profits as it relates to gross profits in terms of sales.

I think the profit factor here is clouding our vision. We know it cost more to produce aluminum than steel, yet we know there are higher profits in aluminum than in steel. We know we can build many things with aluminum better with about 15 percent profit, but here with cement we are producing 37 percent profits, plastics with 21 percent profits, aluminum with 25 percent profits.

I am concerned we are considering our energy requirements and projected shortages on the basis of continued increases of technology that is perhaps producing higher profits, but it is making greater demand upon the use of energy and in many instances creating greater environmental, ecological problems.

Now, would you care to comment on this problem?

Mr. DOLE. Well, Senator Hatfield, and I might remark, Mr. Chairman, this seems like old times when Mr. Hatfield was my Governor in Oregon and I would come up to him with many ideas and I would have to undergo a very strong and searching reply to him and not only once, but several times, so the question that the Senator is posing today is typical of the deep and searching inquiries that he does make.

Now, first, Senator Hatfield, I would like to point out that when it comes to profits, that that is the name of the game here in this country of ours. Until we go away from a free enterprise system, the making of profits is what allows us to search for other materials in order to bring many things that we consider as our industrial society.

I know hear a lot today about the people who feel that our industrial society is not the right way to go. But it has been my observation, and I am sure it has yours, that more people want into this society than want out.

Now, as to our demands for energy, it is not the electric toothbrush, it is not the electric can opener, that cause these demands upon our energy. It is the building of a home for this 20 or 30 million people that we are going to have here, that are here already, now, not coming. It is the tearing down of some of our older slum areas. It is the moving of transportation.

Here we have—although it might be cheaper to move by train than by car, I would hate to have a train come to my house or apartment to deliver my goods. Each mode of transportation has its own place within our industrial society.

Now, as to the environment, we are going to have a greater quantity of material, and energy is what produces the material. It is energy that is going to attack the problems of the environment. As the President noted in his June 4 message, it is clean energy that is needed and this is why we feel that gas, which is the cleanest of all the energy forms, is important.

What we are doing is converting a dirty fuel, coal, and coal is our largest known energy resource, to a clean fuel.

So, I would say in summation, Senator Hatfield, that, yes; we are concerned. Yes; we are doing something about it. I had the pleasure of talking not too long ago in New York before a very significant group of architects and I think that they are getting the word now on the necessity for conserving the use of energy as noted in the President's

clean energy message in which he charged the special consultant for consumer affairs to focus on costs and come up with ideas for the saving of energy in households.

The clean energy message noted that the FHA had to specify better insulation. The facts are that in years past we have dealt from a position of plenty as far as energy is concerned and now we are in a position of scarcity and we have to conserve more.

Senator HATFIELD. I appreciate very much the comments of the Secretary. I don't think we are in any basic difference in basic commitments or theology. It is not a question of profits or no profits, it is a question that we have bigger profits that demand certain prices and certain problems that are created with the environment and the ecology.

When you go into plastics and some of these other fibers, you are producing materials there at higher profits, but at the price of creating ecological problems that nature cannot recycle. When you are involved in these things, to me I think we are reaching a point where we have to make certain judgments. It is not a question of delivering furniture to ones home in a crowded urban center, it is a question whether or not we require transportation or create certain incentives to bring about that result of long-range transportation by rail and short hauls by truck into the areas.

Again, it is not an either/or. It is a question of whether we produce a point of aluminum at a higher demand upon our energy source than if we produce the same product or requirements in the field of lumber. To me, though, it is foolish to believe that we can go down the road, citing new nuclear plants, which I support, gasification programs which I support, without asking ourselves some questions as to whether or not we are conserving the energy we are using now and getting the most we can for the investments and for the future generations that will have it or whether we are just going full-steam ahead in a consumer oriented economy that has no known limits to its appetite.

In fact, if anything, it is doing everything to increase the appetite, I sometimes wonder if advertising isn't one of the things we are going to have to look at very carefully soon, even as it relates to energy. Advertising that creates the appetite, increases the appetite for gimmicks or gadgets that demand more power all the time, more energy.

You say it is not electric toothbrushes, but you multiply that with electric dryers and all of these highly specialized things that plug into the power requirement, I just don't think we have unlimited sources of energy that we can afford this kind of almost a gorging of ourselves with this consumerism that is rampant today with no limitations and in attempts to put brakes on it, making us soft in many ways, making us so affluent that we have lost sight of even our neighbor's needs because we have to have another gadget.

I think this is a value thing. I am not sure the Government can set a limitation but it can try to limit their own intake and their own demand.

Mr. DOLE. May I respond to that, Senator, by saying this searching for what our values and goals are is a continuing process and quite obviously we are in a position now, here in this country, where these things are being given deep and great consideration.

As I have said in many of my speeches, in the past we have not been practicing full cost accounting within the energy area. We have

been charging things against the environment that we should not have that now are going to find their way into the books, the costs, with the net result that energy is going to have to go up in price.

I think when the full cost accounting principle does come into effect and the costs of cleaning up our air and water and our mined lands are taken into account, then there will be a reduction in the waste of energy and a better sorting out of priorities as far as the use of energy is concerned.

As far as the sales of materials, I would like to quote from one of my speeches that I made before the American Bar Association on July 6, and I say:

Moreover, we have been told that just to meet 1975 particulate standards in seven large cities will require an additional volume of gas equal to 15 percent of the total consumed by the nation. That is 3.3 trillion cubic feet a year, and there is no prospect this much gas can be made available. In every case of major concern, pipeline distribution is now focused upon protecting residential at the expense of industrial power plant loads. Yet the sales pitch persists in many cities to get people to use gas to heat their houses. The newspapers are well along with their seasonal warnings about the potential shortage of electric power to meet peak demands this summer. We have been reading these warnings every summer for at least the past three years. Meantime, in the winter months we read advertisements to take advantage of off-season rates. I have the impression somebody isn't getting the word.

This is the way the administration is trying to get better use of material. I was very pleased to see, Senator, in last Monday night's presentation of the Festival at Ford's, the American Gas Association cautioned people to conserve the use of gas, and gave them lessons on how to do it. People are now getting the word.

Senator HATFIELD. Well, I think they are, but again I am not sure that it is other than just an advertising gimmick on the part of some, and it is going to take far more than just advertising.

I want to return to my question, are we doing anything in the department to make studies or material available showing the choices we have to establish these priorities? Where we have the choices of using this type of transportation system or this type of product as opposed to another, and requirements of energy in comparison to the choices?

Mr. DOLE. I don't believe it is that simple. I think there are many uses for aluminum in which steel will not serve as a substitute. But you do have at the market place, and within design of materials, places where you can use aluminum for copper, copper for iron, iron for plastics, and so on.

Now, as to what the department is doing, I call your attention to the fact that the administration is pushing the mined land reclamation bill which I had the pleasure of testifying on before this committee earlier this week. We have studies underway for the use of MHD which would hopefully increase the more efficient use of energy. We have studies on the availability of materials within the United States. We are trying to make a resource study and survey within the Bureau of Mines on better utilization of materials. We have studies on the removal of sulfur from smelter stack gases.

Yes, to answer your question, we do consider choices. We have this under study, but it is not a simple choice of whether you are going to have all iron or steel in place of aluminum. It is a matter of the best utilization and I feel the best place for that to take place is in the marketplace.

Senator HATFIELD. Well, I would thoroughly disagree with your conclusion. I would agree it is not an either/or. I certainly don't imply that we must abolish the use of aluminum, but it is the very marketplace that has created these problems. It has been the lack of knowledge of the general citizen when he goes into the marketplace and becomes subjected to all the high pressure and high powered advertising that creates in that consumer the feeling that he has got to have it or that it is a far preferable item to something that could do the job just as well.

I go back to simple examples of detergents and soaps. Good Lord, I was raised on White King and Fels Naptha, and it worked just as well, but today you can't even find it.

My problem is that the marketplace created this problem. I think government is going to have to do something far more definitive to arrest this type of trend and establish these priorities, or at least point them out so the people can have the voice in it.

Let me point out something else, unless we are willing to take this middle road that I am advocating this morning, the time is running out on the whole question of resolving these problems on a middle road approach because the extremists who put everything into a polarized relationship between ecology and economy, from the standpoint of reality of economics, the ecologists are going to win and they are proving that right down the line. They may not win on Amchitka, but they are going to win on other cases, and they have been winning on them.

I think it is rather an extremely difficult situation we find ourselves in to let the extremists become the spokesmen for the option either/or when there is a solid middle ground here that can be analyzed and established by information, understanding, choices and priorities of saying, all right, we are going to utilize trucks, we are not going to run the trucking industry out, but we are going to put certain restrictions or certain incentives to increase rail traffic. We are going to use aluminum but also lumber and steel and it may just be a little extra difficult to abolish the nonreturnable bottles or we are going to put a thing like Oregon did in legislating on that question.

These are examples of the middle road where we don't get ourselves in an either/or situation. Unless the administration does more than give Mrs. Knauer some pats on the back which to me is fine for the kind of structure she represents, that is not going to solve this problem.

We are going to solve it right down here where we are making decisions or priorities of energy.

Thank you, Mr. Chairman.

Senator Moss. If I may intervene, your assignment, Mr. Secretary, is in the field of minerals and energy in the department, and while I agree with a great deal of what the Senator says, it is not your responsibility to make such a policy decision. We do have a number of witnesses sitting here who we must get to today, so I would be happy if we could continue the review of coal gasification development.

Senator Anderson has a question.

Senator ANDERSON. Mr. Secretary, the second part of your statement, the committee is also well aware of the Nation's declining ability to provide future natural gas. Do you have some figures to show that?

Mr. DOLE. I beg your pardon?

Senator Moss. The decline in the reserves of natural gas, do you have any such figures?

Mr. DOLE. Senator Anderson, the decline in the reserves of natural gas have been very dramatic in the past few years. We have gone in a very short period of time from a reserve to production ratio of 20 to 1, which we were in 1960, down to a reserve to production ratio of around 12 to 1, utilizing the Alaskan reserves, 13.26 to 1 in 1970.

Here in the lower 48 it is 11.9 to 1.

Now, in 1959 we had the reserve production ratio of 21.68 to 1. So, our reserve to production ratio has gone down. Now, our additions to supply, our reserves are actually a little bit larger. Well, they are about the same as they were in 1969. We had 261 trillion cubic feet in reserves in 1959; in 1970 we had a reserve of 259 in the lower 48, or 290 including Alaska. But our increase in use from 1950 to now has been very large.

Senator ANDERSON. In the third paragraph you say industry, with respect to natural gas, has fallen behind needs. It is the same sort of story again, do you have figures for that?

Mr. DOLE. Yes; your question as I understand it, is the need for more gas than industry can supply at the present time.

Senator ANDERSON. Well, no, not completely. I do know there have been some very fine gas developments in the world and I know of the oil available in Alaska. Aren't these still available?

Mr. DOLE. Last year we used around 22 trillion cubic feet of gas. We found around 18 trillion cubic feet. Over the past 4 years our finds versus our production have been equivalent to 1 year's supply of gas.

So, although we have found very large sources of gas, we have increased demand for gas.

Incidentally, this is a reflection of what I consider the improper pricing of gas. It has caused the demand for gas to enlarge at a very rapid rate.

Senator ANDERSON. As part of your research program, are you looking at gasification of coal in place, where you don't even have to move it out of the mine?

Mr. DOLE. Gasification of coal in place was attempted by the Bureau of Mines about 10 or 15 years ago. Dr. Osborne, the director of the Bureau of Mines, has this as one of his very great interests. Right now we do not have in sight a program for gasification of coal in place. Hopefully, we can establish within the Bureau of Mines in the years to come such a program but at present we do not have one.

Senator ANDERSON. You did have it at one time, didn't you?

Mr. DOLE. Yes.

Senator ANDERSON. Why was it dropped?

Mr. DOLE. It was dropped because it was an unsuccessful attempt and there are many of us within the department who believe that the site was not good.

Senator ANDERSON. I won't argue the point, but I think this results in a substantial increase in price.

Senator Moss. Thank you, Senator, and thank you, Mr. Secretary. We appreciate your testimony.

We have imposed on your time a great deal this morning, but you have helped us a great deal in making your report which I consider optimistic.

Senator HATFIELD. Mr. Chairman, I want to make sure the record is clear. I would respectfully respond to the chairman that as far as

the pertinence or relevance of my question to the Secretary, I just don't think we can continue on the way we have been going before the Commerce Committee which I serve and which the chairman serves, of listening to the discussions about siting nuclear powerplants to provide us with our energy requirements, coming in here in the Interior Committee and listen to the Department of the Interior talking about gasification programs to help achieve our energy requirements and all of these piecemeal things that are going on, without trying to draw together some national energy requirements which I know we have legislation to set up such a commission, but I think each agency must address itself to the kind of priorities we have in this Nation, and the kind of demands we have in this Nation and consequently I feel very strongly I am going to have to take the position of opposing all of these programs, if necessary, and I am only one person, until we can get some kind of an overall picture about what this Nation is going to do and where it is going, rather than just to try to keep up with each one of these individual areas.

There has to be some kind of a tying in together and correlation. That is the point I was trying to make this morning.

Senator Moss, I concur with the Senator, we do have before this committee, with augmenting Members of Congress and Public Works, the national energy policy study under Senate Resolution 45. We have held a number of hearings and are going to hold more hearings. I agree that we need certainly to establish a national energy policy and I appreciate the comment of the Senator on that.

Thank you very much, Mr. Secretary and gentlemen.

Senator Moss. We will now hear from Mr. Edward A. Walsh, vice president of the El Paso Natural Gas Co.

I would point out that subsequent to our initial hearings on S. 1846 private sector has announced plans to produce gas from coal and other feedstock sources. We are anxious to hear from some of these private companies to find out what they are doing and how this fits into total energy demand.

El Paso Natural Gas Co. is one of those and we are pleased indeed that Mr. Walsh is here to testify.

STATEMENT OF EDWARD A. WALSH, VICE PRESIDENT, EL PASO NATURAL GAS CO.

Mr. WALSH. Thank you Mr. Chairman, and members of the committee.

If you please, I would like to have Mr. Harry Gravitts with me today. He is director of special projects for El Paso Natural Gas Co., resources and development problems.

Senator Moss. Very pleased to have Mr. Gravitts.

Mr. WALSH. Mr. Chairman and members of the committee, my name is Edward A. Walsh. I am a vice president of El Paso Natural Gas Co. El Paso is a regulated gas company that serves 11 Western States through more than 23,000 miles of pipeline. It is a diversified company with interests and activities in petrochemicals, plastics, synthetic fibers, textiles, agricultural chemicals, insurance, wire fabrication, oil and gas production, mining, land development and utilization of nuclear explosives for industrial purposes.

First, let me express my appreciation to the committee for this opportunity to testify in the proceedings of Senate Resolution 45, and to commend the committee and its chairman on this study of the critical energy situation and the effort to explore the desirability of developing national goals and energy policy.

The symposium of October 20, 1971, in this proceeding, brought under one cover a wealth of ideas and information on the serious energy problems of the United States that have heretofore been separated by the natural operation of different interests. We applaud the proceedings and offer our continued support in the future studies.

My contribution today consists of discussion of three primary points. The first is El Paso's evaluation of the natural gas supply shortage as it affects the company's operation.

Second, I will describe El Paso's proposal to construct a coal gasification plant, including the benefits associated with the selection of the Lurgi process for a commercially scaled base load plant.

Third, I will express support for the proposition that further research and development of the technology of coal gasification is urgently needed.

In 1970, El Paso Natural Gas Co. delivered 1.75 trillion cubic feet of natural gas to its customers in the 11 Western States served by the company. This volume represents approximately 8 percent of all the natural gas consumed in the United States last year.

The market areas served by El Paso are undergoing substantial growth requiring constantly increasing supplies of natural gas as well as other forms of energy to keep pace with population and industrial growth. The California Public Utilities Commission in its "Report on the Current Gas Supply Situation in California," dated June 2, 1971, estimated that its needs would increase 1.85 billion cubic feet per day by 1977. It has also been estimated that by 1977, another 500 million cubic feet per day would be required in the Pacific Northwest area.

None of these increments of natural gas supply has, as yet, been committed by any supplier; therefore, a large segment of the western market must go unserved in future years, unless substantial new supplies of natural gas are developed. This is consistent with certain national forecasts of supply deficiencies ranging from 4 trillion cubic feet to more than 7.5 trillion cubic feet per year as early as 1975.

The depression in domestic drilling, coupled with the accelerated market growth due to the nonpolluting characteristic of natural gas, has resulted in a sharp increase in demand for natural gas and a drain on reserves of all natural gas companies. El Paso, in common with most other elements of the industry, began to feel the ebb of gas supply during 1968 and early 1969; in fact, El Paso has not been able to secure any significant new quantities of gas since 1966, with the exception of Canadian gas.

Assuming a 3.2 percent natural gas market growth rate in the future—nonwithstanding an actual growth rate of almost 7 percent since 1945 and the additional demand which can be expected because of the nonpolluting characteristic of natural gas—the prospect of meeting this demand within the next 15 years, according to governmental, financial, and business leaders, is questionable.

With these cold facts in mind, it is incumbent on any company to take steps to supplement its natural gas supplies immediately. We are

convinced we must utilize both conventional and unconventional sources that are available within reasonable economic limits and not rely on any single source of supply to the exclusion of others.

We support additional incentives leading to the increased domestic production of natural gas at the earliest possible date; further testing and development of nuclear stimulatives of "tight" gas-bearing formations in the Rocky Mountain area, research and development of retorting techniques of oil shale deposits, importation of liquified natural gas, importation of additional quantities from Canada, development of Alaska gas reserves, and refinement of coal gasification technology.

Each of the alternatives named here involves years to bring to fruition, but we cannot afford the luxury of time to pursue them in sequence. Even if we assume that the necessary incentives will be afforded domestic producers in the near future, it requires from 5 to 7 years from the date of initial interest in an area to the time when the consumer receives the new supplies at the burner tip. This time is consumed with the necessary seismic work, lease acquisition, drilling, development, and construction of pipeline systems.

Also significant is the time required for regulatory approvals. We are encouraged by the fact that the Federal Power Commission has taken positive steps to stimulate U.S. production but the objective has not yet been achieved. The regulatory process is slowed by the many competing interests which must be heard in adversary proceedings before the FPC. I raise this not as an opponent of due process but in recognition of its braking power on the current attempt by the Federal Power Commission to move quickly. Under the present law, we cannot avoid this delay and we must calculate its effect on our timetable for eliciting increased domestic production.

Under the most favorable assumptions of increased domestic production of natural gas, we believe that the estimated potential reserves will not provide enough gas to satisfy all of our future requirements. For that reason, I would now like to turn to the various means we are relying upon at present to augment our supplies. There are disadvantages to each, and these, I think, argue for the need to look to coal gasification as a partial answer to our energy needs.

The most readily accessible supplemental source of supply is pipeline imports from Canada. Last year these imports totaled approximately 800 billion cubic feet of gas—about 3½ percent of U.S. consumption. Under contracts now authorized by the National Energy Board of Canada, these imports will increase to about 1,200 billion cubic feet of gas a year by 1975; however, our Nation's requirements will continue to grow. The National Energy Board of Canada controls exports under a formula that permits only the foreign sale of gas regarded as surplus over and above a 30-year reserve life; therefore a very large volume of Canadian reserve additions would be required before substantially larger exports are permitted. We must also take into account the fact that the price of Canadian gas is increasing and the competition to acquire gas that becomes available in the future will be strong.

Because of the relative distances involved, Alaskan gas would be still more expensive than Canadian imports. Further, gas from the Alaskan North Slope will not reach domestic markets until an oil line is laid

and in operation. Even if the oil pipeline is approved next year, it will be several years until oil is flowing. There is little reason to expect completion of a gas pipeline before 1976 at the earliest.

LNG imports now represent an insignificant source of domestic gas supply, but rapid growth is expected. By 1980, imports may exceed 2 trillion cubic feet of gas a year and may reach 4 trillion cubic feet annually by 1985. The LNG contribution will directly benefit distributors in coastal markets and indirectly benefit the inland distributors.

El Paso's Algerian project, involving delivery of 1 billion cubic feet of gas per day, is the first one designed to serve baseload needs. This source of supply will require enormous capital investment for the plants, ships, terminals, and storage facilities. The estimate of capital expenditures for LNG generally made in the National Petroleum Council's U.S. Energy Outlook Study—in terms of constant 1970 dollars—is close to \$11 billion by 1985. The cost of LNG delivered to the distributor should range between 75 cents and a dollar per Mcf.

Those prices are comparable with the estimated cost of Alaskan gas delivered to the U.S. markets. Collectively, pipeline and LNG imports may represent from 15 percent to 20 percent of the Nation's gas needs by 1985.

Project Gasbuggy in which El Paso participated with the Atomic Energy Commission and the Department of Interior was the world's first experiment with respect to nuclear stimulation of gas-bearing formations. By using the explosive energy of a nuclear device in tight formations comprised of low permeability rock, it is possible to obtain an increase in gas recovery far beyond that achievable by conventional-completion methods. The nuclear explosive, when detonated deep underground, creates the equivalent of an extremely large well bore and extensively fractures the surrounding rock. The net effect is to convert large volumes of irrecoverable gas in place to producible reserves.

The Atomic Energy Commission is now designing nuclear explosives specifically for nuclear stimulation of natural gas reservoirs. The radiation exposure to people in a market area supplied by gas from a nuclear-stimulated well would be about 1 millirem per year. One millirem per year is less than that which one is exposed to on a cross-country jet airplane ride and less than one-tenth of the additional radiation exposure as a result of living in a home built with brick or stone as contrasted to a frame dwelling.

If Government funding, legislative action, and development of regulatory procedures take place on a time scale consistent with industry initiative, it appears that aggregate production of about 1 trillion cubic feet of natural gas per year from wells in the Rocky Mountains could be achieved by 1985. The cost of such gas is expected to be much higher than conventionally produced gas and probably lower than synthetic gas or LNG imports.

Of all the alternatives considered, coal gasification offers the greatest ultimate potential for alleviating the gas shortage because of the size of the Nation's coal reserves. According to the U.S. Geological Survey, domestic deposits of coal in the lower 48 States total approximately 780-billion tons. More than 65 percent of these reserves are

located west of the Mississippi. Perhaps over one-quarter of this quantity could be extracted with conventional-mining systems, thus offering a tremendous reserve potential. Assuming that half of these reserves will be needed for nongasification uses, over 100-billion tons of the more readily mined coal would be available for the production of more than 1,200-trillion-cubic feet of gas.

El Paso Natural Gas Co. developed an interest in coal gasification in 1953 that led to a research effort on coal gasification in the mid-1950's. Those early efforts provided a basic working knowledge of coal-gasification processes and products. The indications at that time were that the processes were too expensive to develop and that the costs could not be justified at a time when natural gas appeared to be plentiful.

In anticipation of the time when coal gasification would become economically feasible, El Paso took steps to locate and acquire a supply of the basic raw material. The lease site is on the Navaho Indian Reservation in San Juan County, N. Mex.; approximately 35 miles south of the city of Farmington, N. Mex.

El Paso and Consolidation Coal jointly purchased a 40,000-acre coal lease in 1968 from the Navaho Tribe. Consolidation Coal, as operator of the joint lease, has recently completed an extensive evaluation program of the coal reserves. The coal underlying this lease is subbituminous and there are in excess of 600-million tons of recoverable coal under less than 150 feet of overburden. These are all proven reserves and the coal is of such quality that it is adaptable to gasification processes.

After an exhaustive study of the known and experimental methods of gasification of coal, the decision was made to construct a plant using the Lurgi process, which has been used successfully in 14 plants throughout the world. Although the Lurgi process produces a 400-B.t.u. gas, it is the only commercially proven method in the world today.

We heard this morning, it is between 400 and 450, and I will accept that. We have a conservative figure on it.

Since the plant will be needed as a baseload operation at the earliest possible time, it is not appropriate to experiment with any of the unproven processes now under study. The gas produced will be relied upon to meet current market demands.

We concluded that the addition of a methanation step to the basic Lurgi process could raise the B.t.u. value to a level in excess of 900. The process of methanation is currently being used on a commercial scale in various ammonia plants; however, it has not been proved in connection with a commercial plant producing synthetic gas.

El Paso has entered into a contract with a major U.S. corporation to construct a methanation pilot plant which is scheduled to be in operation early in 1972. In addition, Lurgi has under construction a different type of methanation pilot plant in Germany.

We are also watching closely the IGT pilot plant now in progress. The process to be used in El Paso's proposed plant will probably be one of the three described.

The special circumstances surrounding the El Paso situation are such that the 400-B.t.u. gas to be produced by the Lurgi process can be blended into the main line transmission system, with the 1080-B.t.u. gas currently being transported, with no significant reduction in B.t.u.

value of the resulting gas stream. Of course, we expect to realize the 900-B.t.u. value but a lesser B.t.u. would not preclude us from pursuing the benefits of the base plant.

We have a major pipeline that crosses this site. In the event the plant produces 400- to 450-B.t.u. gas, we can inject that in our pipeline and blend it with the 1080-B.t.u. gas currently being transported through the line. Of course, the blend will reduce the overall B.t.u. value of the gas, but not to any detrimental limits. We can still furnish our customers' requirements and utilize this gas.

Of course, I say that because there is the possibility that we will not realize the B.t.u.'s we expect. Our engineers tell us we can expect 900 B.t.u.'s out of the process and that is just a matter of development.

The entry of the gas from the coal gasification plant will postpone the necessity of these large expenditures and supplement the total gas supply. Another advantage is the proximity of the plant to the El Paso transmission system, which will avoid high transmission costs, which would ultimately be borne by the consumer.

In arriving at the decision to construct a Lurgi plant, recognition was given to the following considerations:

(1) None of the other processes currently under investigation will be ready for commercially scaled operation prior to 1980. The impact of inflationary factors alone may more than offset the reduction in costs introduced by refined processes.

(2) During the interim period between completion of a Lurgi plant and a second generation process plant, the Western State customers will benefit from the availability of the gas produced.

(3) Operation of the Lurgi plant will provide the training of technicians and the development of improved procedures and systems that may prove beneficial in second-generation plants.

(4) Components of the plant will contribute to the research currently underway or proposed and can be used, with modification, in other processes.

All of these factors combine to make us believe the time has arrived to commence the construction of a commercial-baseload coal-gasification plant, and it is this proposal we will present to the Federal Power Commission, which will determine whether or not it is required and in the public interest. We submit that it is.

At this point it may be helpful to the committee to describe the complex and give some description of the elements involved.

Basic coal gasification involves adding hydrogen to coal under conditions of heat and pressure to form a synthesis gas composed of hydrogen, carbonoxides, and methane. The carbon dioxide and sulfur compounds are then removed, leaving a usable gaseous fuel of a low B.t.u. content.

At this point in the process, El Paso will add the further step of methanation, which will increase the heating value of the gas from 400 B.t.u. to in excess of 900 B.t.u. per standard cubic foot. This process will be accomplished by chemically reacting the carbon monoxide and hydrogen to produce methane and water.

The gasification plant, which will be located on the El Paso-Consol lease approximately 3 miles from El Paso's pipeline system will be operated by El Paso. The plant will cover about 350 acres. Included in the complex will be coal handling facilities, multiple gasifiers, shift

conversion treating plants, oxygen plants, methanators, compressors, dehydrators, sulfur recovery plants, other support units, and a water reservoir.

Support installations and facilities will include plant road, parking lots, administration office buildings, cafeteria, shops, storage buildings, laboratory, fire station, security stations, and other miscellaneous structures. Facilities will be included in the plant to generate all necessary electrical power. Coal will enter the plant and be stored until needed, at which time it will be crushed to the proper size and conveyed into the gasifiers. It will then enter the gasification process.

The gasification plant, when fully operational, will process about 21,000 tons of coal per day, or about 7.3 million tons per year. The mine supplying this quantity of coal will likely be one of the largest coal mines in the United States. The proposed mining plan is quite similar to that being employed successfully in the numerous surface mines throughout the world.

In addition to engineering studies underway, extensive environmental investigations are in progress by both El Paso and Consol. The impact on the environment has been carefully considered from the beginning of our planning and it will continue to receive foremost consideration in the construction and operation of both the plant and mine.

Our preliminary investigations indicate that the project will have minimum effect on the environment. Air and water pollution are not expected to be problems. Because of the nature of the process, stack emissions will be well below anticipated State and Federal permissible standards. Ash from the coal will be removed from the gasifiers by underwater conveyors and will be returned to the surface mine and buried.

Since the gasification process consumes the water which enters into the plant, the plant will not return any water to the San Juan River. Both the plan for mining the coal and the plan for restoration of the mined area are subject to approval by the Navajo tribe and the Bureau of Indian Affairs. The project must also comply with applicable laws of the State of New Mexico, as well as Federal regulations contained in Public Law 91-190, the National Environmental Policy Act. With regard to the proposed project, no less than four Federal Government agencies will review the project plans. These agencies include the Federal Power Commission, the Bureau of Reclamation, the Department of Interior, and the Department of Transportation.

In conclusion, I would like to make the following observations and recommendations. As I have indicated, El Paso has undertaken this project because of certain fortunate circumstances, foremost among these being our ability to accept natural gas of reduced BTU value, should the methanation stage not perform as we expect.

I didn't mention the need of it here, but that is, of course, one of the considerations we have.

For this reason, this project will not only meet base load requirements, it will concurrently contribute to the progress of coal gasification technology. This alone, I believe, indicates El Paso's position with respect to further research and development. Further, there should be development of lower cost processes required for second or third generation coal gasification plants.

We are of the view that research on a variety of fronts must be undertaken. To this end, it will be necessary to accumulate large sums of money from both the private and public sectors. In consonance with this view, El Paso has contributed to the joint pilot plant of the American Gas Association and the Office of Coal Research \$674,000 a year for the first 4 years of the project.

We would hope that an aggressive research program would develop new efficiencies and alternative methods with cost or other advantages over the Lurgi process. A more efficient process of gasifying coal would repay the money expended on research through lower gas costs.

Thank you very much.

Senator Moss. Well, thank you, Mr. Walsh. That is a very interesting discussion and it does let us know what El Paso Natural Gas is planning down in the Four Corners area.

You mentioned that the air pollution stack emissions would be controlled to meet the standards of the State of New Mexico and the Federal standards?

Mr. WALSH. Yes, sir.

Senator Moss. How much water will this process take? Do you have a demand for a considerable amount of water?

Mr. WALSH. Yes. I believe the water requirements for the Lurgi process amount to 27,000 acre-feet of water per year for a plant that would develop 250 million cubic feet a day.

Senator Moss. Does any of this water get back into the stream, or have to be discharged any place?

Mr. WALSH. None of the water used in the plant is returned to the stream.

Senator Moss. It is all consumed in the process so there wouldn't be any problem with pollution of the water? It will all be used up?

Mr. WALSH. That is correct, sir.

Senator Moss. Do I understand you plan to use about 7 million tons of coal a year in this plant? Is that the figure?

Mr. WALSH. It is 27,000 tons a day, about $7\frac{1}{2}$ million.

Senator Moss. I assume you have reserves that will carry you for a considerable period of time. How long do you plan?

Mr. WALSH. The proven reserves, the lease we are describing here, is in excess of 600 million tons. To put that into prospective, I think that would support three plants the size that we are proposing here of 250 million a day for 27 years.

Another way of looking at it, spot the 250 million a day for 480 years.

Senator Moss. Would this be strip mining of coal in that area?

Mr. WALSH. Surface mining, yes, sir.

Senator Moss. And, of course, you are planning, I am sure, restoration of the area, the problems we have been discussing earlier in this committee this week?

Mr. WALSH. That is right. The plans call for restoration of the voids and covering the area with the soil and seeding it. What we will do, of course, is live up to the standards required.

Senator Moss. We are concerned about the environmental strain in the Four Corners area now from the electric power generating plant. I take it your building of this coal gasification plant will add to that

ecological strain, or do you think you can control your emissions of air pollutants, water pollutants, land disturbance so that there isn't an undue burden?

Mr. WALSH. We are hopeful that we can, and that is our intent. But again, the Lurgi process doesn't emit a lot of air particulate matter. The powerplant that is used in conjunction with the coal gasification plant, if it burned coal, would. But in this case we are planning to burn gas in the power plant, the low B.t.u. gas so there would be a minimum of stack emissions.

In addition to that, we have a sulfur removal unit that will remove sulfur from that which would otherwise be stack emissions, and we will either store or sell that raw sulfur that is produced.

Senator MOSS. Can you remove all of the sulfur from the stack gases?

Mr. WALSH. I think we can remove most of it, I don't know the exact figure. That is what we are saying here, we will remove it within the minimum standard requirements of both State and Federal.

Senator MOSS. I believe you said the lower B.t.u. content of the gas produced would be enhanced somewhat by blending it with other natural gases, but does this lower total B.t.u. cause any problems with your consumers?

Mr. WALSH. No; it does not. I think the impact goes something like this. If you inject 250 million cubic feet per day of 400 B.t.u. gas into our pipeline coming out of the San Juan Basin, you blend it with a stream of about 1,130 million cubic feet a day of 1,080 B.t.u. gas. I don't have the figure here, but I think the figure would be something like 1,065. That is subject to check, and it would not have an appreciable impact on the total stream.

Senator MOSS. I see.

Now, you made application to the Federal Power Commission. If that is forthcoming, then you will be ready to begin at once the construction in the area?

Mr. WALSH. We have not at this time made application to the Federal Power Commission. We are in the process of preparing that application now. We expect it will be filed by the end of this year or the first month of next year, and then through proceedings there to obtain a certificate to construct part of the facility, and we would commence construction after that, if we are granted that certificate.

Senator MOSS. Do you have to also get a sort of clearance from the State of New Mexico?

Mr. WALSH. Yes.

Harry, could you speak to that?

Mr. GRAVITTS. No, sir. As far as the certificates to construct are concerned, that comes within the reach of the Federal Power Commission.

Senator MOSS. They probably require an environmental statement?

Mr. WALSH. Yes, we have to file an environmental statement in compliance with EPA. It will be filed after the Federal Power Commission—the environmental impact statement.

Senator MOSS. Along with your application?

Do you have any questions, Senator Anderson?

Senator ANDERSON. Thank you, Mr. Chairman.

On pages 3, 4, and 5, you refer to the emissions for the type gas emission to be more effective. How much water will you use in that Four Corners area?

Mr. WALSH. I wanted to correct that. I believe I made the statement it will be 27,000 acre-feet per year. I think it is 10,000 acre-feet per year for this plant that we are proposing, Senator Anderson.

Senator ANDERSON. You are sure it isn't 27,000 feet?

Mr. WALSH. No, 27,000 feet would be the figure required if you developed all of the total deposits up there. That would be three of the same sized plants we are talking about. I stated that figure, but the correct figure is 10,000 feet per year for the plant we are proposing now.

Senator ANDERSON. Did you enjoy the work of gas buggy in the early days?

Mr. WALSH. Yes, sir.

Senator ANDERSON. Did it produce results?

Mr. WALSH. Mr. Gravitts has been quite active in the gas buggy program for a number of years?

Mr. GRAVITTS. Well, the results were good in the sense that the test was designed to furnish us with information so that we could then go forward and try to plan intelligently for commercial operations.

At the time gas buggy was designed, we knew that the test would be conducted safely, but there were certain technical questions that had to be answered. Gas buggy did provide us with insights that have defined prediction capability and it made a contribution there, and the further contribution in the planning of a proposed experiment that is in the final design stages now in southwestern Wyoming.

If there is an agreement with various Government agencies and State agencies that would be effected, within the next 6 months or so we would be in a position to propose such a test.

So, gas buggy was the first and it did make all of this possible. I might also add that we dearly appreciate the cooperation from the State of New Mexico of the various departments and agencies and the people themselves as individuals that made a contribution by assisting us, providing information, guidance where it was required.

Thank you.

Senator ANDERSON. Mr. Walsh, in your opinion what kind of contribution can this make to the whole gas supply problem?

Mr. GRAVITTS. We feel by 1980, assuming things fall into place, and let me tell you what they are, in the first place, under the Atomic Energy Act, nuclear explosives for commercial or practical utilization are not available. They are made available through the Atomic Energy Commission only for experimental or demonstration purposes. So that we do, in fact, need the enactment of legislation to make them commercially available on a service contract sort of basis, we would assume, with the Atomic Energy Commission.

In addition, there would have to be the enactment of standards for what would be marketable quality gas produced as a result of utilizing this technology.

I think we can state categorically at this time that there is no question in our mind but that the consumption of such gas would not constitute a hazard of any kind. However, in order to be able to do that as a practical matter, regulations are required.

Senator ANDERSON. Is there an agreement between the gas industry and the Government as to what the natural gas reserves really are? Is there a common figure that you both agree on?

Mr. GRAVITTS. There are various estimates that fall within a fairly close range as to what are proven reserves today. There are differences of opinion as to what the remaining resource base is and what you might consider will ultimately be proven reserves.

I might add, one of the problems we are looking at is the changing nature of the business in that we believe that from here on forward more than 50 percent of the gas, regarding the finds, is going to be below 15,000 feet. Those are depths that we are projecting where you normally don't find a lot of oil-drilling activity.

We are looking and speculating about the potential of the east offshore where there are occasions that it has potential, but nothing is known yet. So, there are ranges of estimates as to remaining ultimately discoverable reserves, currently proven reserves. I think there is fairly general agreement.

Senator ANDERSON. Thank you.

Senator Moss. Senator Fannin?

Senator FANNIN. I commend you on the leadership you and your company have been giving in trying to solve some of these problems, especially your project on Algerian LNG. I know it is a very costly project.

In trying to see exactly where we are going from the figures you have given, I assume in 1970 we consumed approximately 21 trillion cubic feet of gas in the United States and that, of course, relates to a figure that you estimate in your statement, we will have a shortage in supply ranging from 4 trillion to 7½ trillion feet a year as early as 1975, and we can only pick up as I see from your statement on page 5, you estimate somewhere between 2 and 4 trillion cubic feet by 1980.

I would say by 1975 we will be in a pretty serious position, will we not, if we can't solve some of these problems?

Mr. WALSH. We think so, Senator Fannin. Another way to look at it, I think if you look at the year 1980, which is a little closer to us than looking out at the total future requirements of the country, one estimate of our situation at that time that we think was realistic was that the potential demand will be about 93 billion cubic feet per day and the indicated supply at that time of the U.S. production will be about 54 billion cubic feet of that 93.

The imports from Canada will be about 4.5 and LNG imports, coal gasification and LNG will make up about 4.5 billion, making a total of 63 and leaving a deficit in 1980 of 30 billion feet a day.

Senator FANNIN. You said by 1980, how many trillion cubic feet would be available?

Mr. WALSH. It would be 93 billion cubic feet a day.

Senator FANNIN. So, it is 30-some billion, so it is an increase of at least 50 percent over what was used in 1970 in a 10-year period?

Mr. WALSH. Yes.

Senator FANNIN. That is what is alarming. If we are going to be that dependent upon LNG and the source is going to be Algeria or countries that far away, what would happen if those resources were cut off and how could we replace that energy in an emergency, or could we?

Mr. WALSH. When we entered into the agreement with the Algerians for the project that we have before the Federal Power Commission now, it was decided that the Algerian Government agency would build all of the facilities in Algeria; that El Paso's subsidiary companies would own only the ships, the LNG cryogenic tankers to transport that gas to the United States.

We think there is flexibility in that. We think there is an enormous amount of protection that the Algerian Government, having built all of the facilities in their country, would continue to supply. But in the event something happens that we don't perceive now, we do have the flexibility to send the tankers to other sources.

Senator FANNIN. That is what I was wondering. Of course, the tremendous problem you have is facilities for that immense amount of product to carry it. No other country has expanded their facilities in their ships to carry LNG?

Mr. WALSH. That is correct.

Senator FANNIN. I was just wondering what might happen. Are there storage facilities concentrated to a great extent in the United States? I realize how difficult it is to store and I was wondering if you might have so many days supply in storage?

Mr. WALSH. Yes, the project that we propose delivers gas to two points, one in Maryland here on the Chesapeake Bay, and the other is Savannah, Ga. Both of the terminals have storage facilities for several days storage of gas.

Senator FANNIN. I notice you are doing some experimental work in some of the Western States on underground storage, blasting out caverns. Is it possible to take a chance on LNG in caverns of that nature?

Mr. WALSH. I think there are projects underway to do that. I think it is possible.

Senator FANNIN. Is it feasible?

Mr. WALSH. I can't say from my own experience, Senator, because I don't have any figures available to me on the underground storage of LNG.

Senator FANNIN. Within the economics of coal gasification, I don't know what we have actually done as far as coal gasification is concerned. What is the largest plant so far producing the coal gasification process?

Mr. WALSH. The Lurgi process has 14 plants going in the world. I think the largest would be comparable to the 88 million plant we are proposing. You see, we are proposing to build three trains, for 88 million; second and third for a total of 264 million. They have a plant in operation that is comparable to the 88 million plant.

Senator FANNIN. So, you have information available as to the experience of what can be done? We have not a large plant in this country as yet, have we?

Mr. WALSH. No, sir; we have not.

Senator FANNIN. Thank you, Mr. Walsh.

You did say your environmental impact statement would accompany your application to FPC, did you not?

Mr. WALSH. That is correct.

Senator MOSS. We did appreciate your coming here to answer questions, and we are, of course, pleased to see that El Paso is moving into this field and also participating in general industry support of re-

search to be done in conjunction with the Department of the Interior.

So, we are glad to have this in the record. It gives us an indication of what action we can expect. Thank you very much.

Mr. WALSH. Thank you.

Senator MOSS. Our next witness is Mr. George H. Lawrence, vice president and director of American Gas Association.

We are glad to have you, Mr. Lawrence, you may proceed. If you want to summarize or highlight your statement, you may do so.

STATEMENT OF GEORGE H. LAWRENCE, VICE PRESIDENT AND DIRECTOR OF AMERICAN GAS ASSOCIATION, ACCOMPANIED BY MR. FLOWERS

Mr. LAWRENCE. Thank you, Mr. Chairman.

My name is George H. Lawrence; and I am vice president and director of Government relations and services of the American Gas Association, a nonprofit trade association, representing some 300 distribution and transmission member companies serving the gas requirements of about 92 percent of the ultimate gas consumers in this country.

Gas powers 43 percent of industry in the United States, including some 28 percent of the Nation's electric power. Gas presently serves more than 42 million meters through 900,000 miles of pipelines in all 50 States. This national network of pipes and mains, with a total investment of \$46 billion serves some 150 million of our population.

The A.G.A. has in the past several months had the occasion before a number of congressional committees, including the Senate Interior committee, to document the nature and extent of the gas supply problem. This problem and the public interest in alleviating it have now been widely acknowledged by public officials, industry spokesmen, the financial, industrial, and academic communities, environmentalists, consumers and the President of the United States in his clean energy message of June 4, 1971.

Since 1956 gas consumption has more than doubled while exploration and drilling by producers has declined steadily to about one-half of its 1956 level. The result is that the cushion of excess gas reserves, which the industry had enjoyed since the proliferation of interstate pipelines following World War II, is gone and pipelines and distributors cannot now contract for their needs. In 1956, for the first time, gas consumption exceeded new reserve additions—and by 40 percent. Yet, in 1968, demand hit a peak annual increase of 8 percent. Again in 1969 and 1970 new reserve additions, excluding those in Alaska which are not yet marketable, fell short of gas consumed.

The gas industry, well aware of the significance of the role which it has to play in the total welfare of our nation, has long been concerned about the growing natural gas supply problem and its ability to meet the increasing demands for industrial, commercial, and residential uses. Natural gas now supplies one-third of the Nation's total energy requirements, and the industry's ability to meet not only the anticipated increased future demand, but also to keep pace with current needs, is a problem deserving high national priority.

As a result of this deteriorating gas supply situation, the gas industry simply cannot expand at the rate market demand justifies, that is at the rate consumers want and need this highly desirable product.

Many gas companies clearly recognize their inability to meet the full requirements of market demand. Market allocation and curtailment proceedings by pipeline companies are becoming the order of the day at the FPC. This, of course, results in corresponding limitations by distribution companies. Many companies already have been forced to impose severe limitations on new industrial loads and we are seeing the beginning of curtailed deliveries to existing industrial customers and the denial of prospective commercial and residential customers.

A recent example was described on the front pages of newspapers in the Nation's Capital last week. The Washington Gas Light Co. announced that for the foreseeable future it would be able to take on new customers only in single family dwellings. This means that energy in the Metropolitan District of Columbia area for industry, commercial uses, and multiresidence apartments must be supplied by something other than clean burning natural gas. This situation is repeated elsewhere in the country. However, it is a situation which does not have to exist permanently and there are impelling public interest reasons which justify its correction.

Immediate steps which can and should be taken to solve this problem are those which would stimulate exploration to develop the potential supplies of 850 trillion cubic feet estimated to exist in the contiguous 48 states:

More frequent and regular land lease sales, including offshore areas.

More realistic price levels to restore badly needed incentives for exploration and drilling.

More stability in the sales contract of producers committing supplies to interstate markets.

Encouraging steps are underway in each of these important areas by the Department of the Interior through its offshore leasing program, by the Federal Power Commission in recent area rate decisions, and by the Congress through amendments to the Natural Gas Act introduced by Senator Ernest F. Hollings, as S. 2467 and by Senator Clifford P. Hansen as S. 2505. These steps deserve and need the support of Members of Congress—indeed of all public officials.

While such steps would make a major contribution toward solving the gas supply problem, it is accepted fact that they alone cannot add the huge new supplies necessary to meet demands which have averaged 7 percent per year during the past several years, and could have been much higher but for the restraint of the impending natural gas shortage. This industry must look to additional potential sources to meet these demands.

Development of the Alaskan North Slope and Canadian Arctic, with a potential 800 trillion cubic feet of gas, pipeline imports from Alberta and British Columbia Provinces in Canada, hydrocarbon reforming projects, nuclear stimulation of tight formations, and the development of a domestic coal gasification industry, all must of necessity be developed in order to meet the anticipated demand.

This last-mentioned potential source for new gas supplies, coal gasification, in all probability constitutes the most promising single technological advancement in the field of developing substitute natural gas supplies, and will undoubtedly contribute significantly to the alleviation of the present and ever-growing natural gas supply crisis. The establishment of a coal gasification industry would utilize the virtually unlimited coal reserves of this country in a manner most

compatible with our current environmental needs. Coal gasification will permit this vast source of domestic energy to be delivered to our major consuming centers as clean, sulfur-free gas through a 900,000-mile network of underground pipelines.

On July 28, 1971, AGA testified before this committee on the need for a domestic coal gasification industry. We described AGA research efforts to date, and specifically outlined the proposed joint Interior Department-AGA accelerated research program which would evaluate the principal-known processes through the pilot plant phase. At this point, Mr. Chairman, I wish to reiterate the AGA position on the legislation which was the subject of those hearings.

We continue in our support of S. 1846: to establish a coal gasification development corporation. Let me again state that the proposed corporation appears well suited to perform the essential final step for translating into commercial demonstration the pilot plant research findings through the creation of the necessary corporate entity and organization. However, as we also stated on July 28, and do so again today for the record in these proceedings, AGA believes that the pilot plant research program is a necessary forerunner for the most efficient and successful program of commercial demonstration on which an entire new coal gasification industry would be based.

Subsequent to that testimony, the Department of the Interior and AGA formally signed an agreement for the joint funding of an accelerated research program on the pilot plant evaluation of several methods of converting coal into pipeline quality gas. This committee was previously furnished a copy of the AGA proposal of January 22 to the Interior Department, and Secretary Dole has placed in the record this morning a copy of the original chart and the agreement of August 3, 1972, between AGA and Interior implementing the proposed program.

This agreement furthers a 25-year research program funded by AGA in which the Office of Coal Research has financially participated since 1964. The program is dedicated to a 4-year pilot plant research effort at a cost of \$30 million a year, of which \$20 million will come from the Federal Government and \$10 million from the gas industry.

AGA experience in the field of coal gasification research dates back to 1946 and encompasses a broad gamut of activities, including those which led to the construction and operation of the \$10 million pilot plant in Chicago, which produces 1.5 million cubic feet of gas per day from coal. This project, utilizing what is known as the Hygas process, is jointly funded by AGA and the Office of Coal Research, and carried out by the Institute of Gas Technology.

A principal benefit to be derived from the Interior Department-AGA program is not only to accelerate research on each of the most feasible known methods, but to conduct it in a coordinated manner which would permit maximum time and money being devoted to those components of all the processes which test results confirm as offering the greatest contribution. Likewise, the less desirable or technically condemned components can be laid aside at the earliest time. This would simply enable more efficient concentration of time, money, and facilities to obtain the most technologically advanced answers in a period of 3½ to 4 years.

There have been several recent announcements of intentions to study and to build full-scale commercial coal gasification facilities. However, these proposals are not inconsistent with the Interior-AGA accelerated pilot plant research program.

Indeed, quite to the contrary, AGA, as well as those member companies announcing plans for commercial installations, view these pilot plant evaluations as a necessary step which should be continued and which should be supported by both Government and industry. The tangible manifestations of this attitude by those member companies is their financial contribution to the AGA \$10 million-per-year portion of the joint Interior-AGA program.

There are sound and varied business and public interest reasons why individual companies are prepared to proceed now with the initial commercial ventures. I am sure their representatives, who will appear in these proceedings, will expand on them.

El Paso Natural Gas Co. first announced plans to build a commercial scale gasification facility utilizing the Lurgi process for converting coal into substitute natural gas. Then the FMC Corp. publicized its intention to solicit financing through a consortium of companies for a plant to gasify coal by a process known as Cogas, which I understand will be described in these proceedings. Then on October 27, AGA member companies, Pacific Lighting Corp. and Texas Eastern Transmission Corp., announced their intention to study the feasibility of a major commercial plant in northwest New Mexico, which contemplates using the Lurgi process.

The Lurgi process is one of the seven gasification techniques which AGA has been evaluating, and it is the only process which is presently in commercial operation, having been commercially applied in Germany since the mid-1940's to provide a gas of relatively low B.t.u. content.

The AGA evaluation has, however, revealed that a number of other processes show as much or more promise than the Lurgi method. Perhaps certain aspects involved in Lurgi gasification will be utilized in the final process or the combination of processes to emerge from the AGA-Interior pilot research program. Limitations of the Lurgi process center on the fact that it cannot directly use caking coals but must use lump coal which cannot be pretreated. Thus, Lurgi gasification cannot directly use coal fines which modern coal-mining methods do generate. Such fines are in the form of coal dust and small coal particles which tend to coagulate and are not suitable for gasification in the Lurgi process, although these fines may be compressed into larger coal briquets which are then usable in the Lurgi process.

It should be noted that coals in certain Western States are of such a nature that they are better suited to the Lurgi process than are coals found elsewhere in the United States. This is particularly true of subbituminous coal which is readily available to the El Paso site, and the Pacific Lighting-Texas Eastern site, and should provide an adequate supply for these Lurgi gasification projects. The particular circumstances of these companies undoubtedly do warrant their construction of a Lurgi plant. However, it seems doubtful that the Lurgi system as presently constituted will become the exclusive process for a domestic coal gasification industry.

Further, I should emphasize that AGA is greatly encouraged by these early expressions of willingness to move forward with commercial projects. This means that the pilot plant research results, as well as technological breakthroughs that might occur from other sources, are most likely to be put to the practical use of satisfying major consumer needs at the earliest possible date. And the primary AGA goal is to solve the gas supply problem in the quickest and most economically realistic way.

I note from the FMC testimony in these proceedings that they are in agreement with the need for the basic Interior-AGA research. The FMC statement cites the need—for Government to continue vigorous research on coal gasification and particularly in those elements where innovation is needed. This is exactly what the Interior-AGA program is designed to accomplish. The innovation most needed is in the area of methanation; that is, how to get the gaseous hydrocarbon components from coal gasification up to the quality of natural gas which is essentially methane with a heat content of about 1,000 B.t.u.'s per cubic foot. The gas industry has long known how to manufacture low B.t.u. gas. This is what the gas industry was based on before the advent of natural gas.

As stated earlier, the Lurgi process has been used in Europe to make 400–450 B.t.u. gas for years. But the aim now, by the process called methanation, is to elevate that B.t.u. content from 400–450 to about 1,000 B.t.u.'s per cubic foot so it will be fully interchangeable with pipeline quality natural gas—and to do this in the most economically feasible manner. This is the goal of the gas industry's coal gasification efforts. We expect to have continued development of the vast potential supply of natural gas which is usually 98-percent methane with a B.t.u. content near 1,000. We expect to develop substitute natural gas from our Nation's vast coal supplies so it can be blended with these natural gas supplies in any pipeline system. However, we need the Interior-AGA pilot research effort to confirm the method which is technologically best and most economical.

At this stage of gasification research the state-of-the-art is such that our own investigations do not presently warrant selection of any single gasification process for broad commercial application. It is particularly significant in this regard that El Paso, Pacific Lighting, and Texas Gas Transmission are among the largest contributors to the AGA special subscription fund for the AGA-Interior Department joint accelerated research program. Again, this is clear evidence that these companies believe that significant contributions can result from the basic pilot research program, especially the development of a process more usable throughout the United States. Each of these companies is vitally concerned with the solution of the Nation's overall gas supply problem and has been in the forefront of the principal efforts devoted to that solution.

However, again, a very basic question with respect to demonstration plant technology is that of determining the most economic methanation techniques to convert the resultant gas into a high B.t.u. pipeline quality. The construction of any plant at this time does not by any means indicate that one type of gasifier is the ultimate answer to coal gasification. Additional processes under development by OCR and AGA are urgently needed to give our Nation the most reasonably

priced supplemental gas supply. We view the pilot plant research as an essential prerequisite not only to development of the optimum system for coal gasification but also for maximizing the cost benefits to be derived from the substantial investment this industry will have to make in the full scale nationwide commercial development of coal gasification processes. We view the pilot plant research as a necessary step to assure the gas industry and the Government that a coal gasification industry will be based upon the best technology which will insure the greatest efficiency at the most reasonable cost.

Should any members of the committee require additional information or desire that AGA address itself to any of the points presented in this statement, we would be pleased to supply that information or appear before the committee at a later date and respond to particular questions.

AGA appreciates this opportunity to once again express its views on the vital issue of seeking alternative solutions to the natural gas supply problem.

We would be pleased to attempt to answer any questions you may have.

Senator Moss. Thank you, Mr. Lawrence for a very fine statement. I am most pleased that you were here.

I have one or two questions but you probably heard the bell and saw my colleagues leave. That means there is another vote under way. I think, therefore, we will take our lunch on recess and come back at 1:30 p.m. I wonder if you could return at 1:30 p.m., if there are some questions that my colleagues have, and I do have one or two that I would like to ask.

Mr. LAWRENCE. I will be here.

Senator Moss. We will be recessed until 1:30 p.m.

(Thereupon, at 12:05 p.m., the hearing was recessed, to reconvene at 1:30 p.m., the same day.)

AFTERNOON SESSION

Senator Moss. We will resume our hearing.

Mr. Lawrence has finished his presentation and there are one or two questions that we want to ask of him before we move to the next witness.

One thing that interested me, Mr. Lawrence, in your presentation and intrigued me, is that you expressed again your support for the American Gas Association for S. 1846 saying that we did need a demonstration plant and it would accelerate industry. On the other hand, the Department has indicated that they would oppose 1846 as being unnecessary.

Both of you are running in harness on the contract. Is there any explanation of that difference in point of view?

Mr. LAWRENCE. I don't think there is any difference on the phase of the research in which we are presently running in harness; namely on the 4-year pilot research, but AGA and the Department and the administration have agreed that the demonstration plant phase, to whatever extent we are operating in harness, is entirely negotiable. It occurred to us, upon seeing your proposal, S. 1846, that this did in fact constitute a logical vehicle for a joint Government-industry venture in the demonstration plant phase.

What we did want to urge was that there be changes in the bill that would ascertain that it would be compatible with the pilot research phase.

Senator Moss. Is it your feeling that by using the mechanism of 1846, we might sooner get to the demonstration plant stage because we could take advantage of the pilot plant research now going forward.

Mr. LAWRENCE. That is it exactly, Mr. Chairman. Just as we are encouraged by the fact that many of our member companies and others are announcing commercial ventures now. We think that the bill and the demonstration plant vehicle, 1846, would move ahead the timetable when we would in fact confirm commercial feasibility.

Senator Moss. You, of course, pointed out in your statement the growing shortage that we are moving into in the gas area and I think you mentioned other possibilities, but do you see any place that is as promising as getting into the coal gasification? Are there other developments that are of equal or better promise than that?

Mr. LAWRENCE. I guess not, really, for the long-range permanent contribution to the energy needs of this Nation. I think, actually, Senator, there are three main areas to solve the gas supply problem. One is the full development of our domestic potential in the lower 48 States of which the estimate total is 850 trillion cubic feet over and above proved reserves. That is a great deal of gas. The proved reserves in the lower 48 total about 260 trillion cubic feet now and \$46 billion investment in transmission and distribution facilities based on that 240 trillion cubic. So when we are talking about 850 trillion potential, that is a big potential.

Similarly, if area No. 2, I think it offers a real promise for major contributions to the gas supply problem, the Prudeau Bay area of Alaska and the Canadian Arctic. There again the potential appears to be another 800 trillion cubic. So the total is like 1,800 trillion cubic feet and the third area is that of coal gasification.

Senator Moss. Do you see any problems in being able to get sufficient water rights in these demonstration plants?

Mr. LAWRENCE. This was definitely a problem of concern to the gas industry when we really began to get serious about the coal gasification as a permanent contribution to our industry. Not being in the coal business or the water business, AGA did undertake an expensive study to confirm the fact that there were sufficient coal reserves and sufficient water reserves to conduct commercial coal gasification.

This study, which was kept highly confidential, did confirm the fact that there were some 176 sites that would support commercially feasible plants in magnitude of 250 million cubic feet per day.

Senator Moss. Well, I surely appreciate your testimony and I will refrain from further questioning because we have other witnesses here and a lack of time. But I commend the American Gas Association and its members for this willingness to go ahead and put out the resources and the effort operating the program that you are now in pursuant to the agreement with the Department of Interior and also your support of the concept of the demonstration plant.

Senator Moss. Our next witnesses are going to come together as a panel at the table, Mr. George Ewing, vice president of the Texas Eastern Transmission Corp., Mr. Alexander Wilson, president of Utah International, Inc., and Harvey Proctor, president of Pacific Lighting Service Co.

We are pleased to have you gentlemen here with us and if you take your place at the table, we will ask you to proceed in whatever order you decide among yourselves, not necessarily in the order in which your names are called, if there is any way that you have for division of that.

STATEMENT OF GEORGE H. EWING, VICE PRESIDENT OF TEXAS EASTERN TRANSMISSION CORP.; ACCOMPANIED BY ALEXANDER M. WILSON, PRESIDENT, UTAH INTERNATIONAL, INC.; AND HARVEY PROCTOR, PRESIDENT OF PACIFIC LIGHTING CORP.

Mr. EWING. We will stick to the order that we had there, if it suits you.

Senator Moss. All right.

Mr. EWING. Mr. Chairman, may I say for Texas Eastern Transmission Corp., how pleased our company is to have the opportunity of appearing before this committee and submitting some of our views on coal gasification developments.

My name is George H. Ewing and I am a vice president of Texas Eastern Transmission Corp. I obtained my formal education at Texas A. & M. University, from which I was graduated with a degree in civil engineering. For the past 23 years, I have been employed by Texas Eastern. My responsibilities are in the areas of engineering and supplemental fuels development.

Texas Eastern Transmission Corp. is a Houston-based business that has grown to become one of the primary energy suppliers to the Nation. We operate two major natural gas pipeline systems supplying gas to both the east and west coasts and a large common-carrier petroleum products pipeline system.

The company also engages in exploration and production, refining and other petroleum-related activities both in the United States and overseas. In 1970, Texas Eastern delivered 1.3 trillion cubic feet of gas and nearly 89 million barrels of liquid petroleum products and our gross plant properties related to the energy business exceed \$2 billion.

We mention these items about the company merely to make the point that Texas Eastern is a large and well-experienced energy-supplying organization. We intend to remain in the energy business and the fund of knowledge we have accumulated will be used in new energy-related endeavors, such as a proposed coal gasification plant in New Mexico that was recently jointly announced by Pacific Lighting, Utah International, and Texas Eastern.

At Texas Eastern, the concept of gasifying coal is certainly not new. Our work in this area began in 1954, motivated by our philosophy that conventional natural gas is a limited resource. Our individual work continued until 1960. At that point, two other companies which had coal gasification processes that were advanced for the time joined Texas Eastern in a new research effort.

By 1970, it was recognized that our gasification technology was still years from being commercial, and we began to direct our coal gasification activities toward programs that would permit the construction of a plant as soon as possible. At the same time, we continued to sup-

port long-range research of coal gasification processes, some of which Texas Eastern had helped sponsor from the start. This sponsorship of AGA-IGT and other coal gasification programs will continue.

I don't think there is any need to substantiate for this committee the fact that there is a serious and escalating imbalance between availability of new natural gas reserves and the growing consumer demands for this reliable, safe and nonpollutant source of energy. The charted record of this imbalance is clear and, in Texas Eastern's opinion, it is not likely that a solution for the natural gas shortage will be found easily or quickly.

Reflecting this, Texas Eastern established a supplemental fuels division, which embarked on development of supplemental gas supply projects. Our first synthetic gas program is a proposed facility that is projected for installation in the heart of the market area of our eastern gas system. If needed certification is received this year, this plant will reform naphtha-range liquid petroleum feedstocks to yield 500 million cubic feet daily of pipeline-quality synthetic natural gas—SNG—by late 1973.

For many years, our engineers have been looking throughout the United States for coal reserves and associated water supplies that would be within economic distances of both of our gas pipeline systems and market areas. Just a few months ago, Texas Eastern joined Pacific Lighting and Utah International in a plan to possibly develop a coal gasification project in the San Juan Basin.

Then on October 27, the three companies announced that a series of intensive studies will be completed by the middle of 1972 to determine the economic and technical feasibility of a coal gasification plant in northwestern New Mexico. In its first phase, the proposed complex will process approximately 7.5 million tons of coal annually to yield about 250 million cubic feet per day of nonpollutant synthetic gas.

Hopefully, all approvals can be obtained from regulatory agencies without great delay and the facility startup can be accomplished in late 1975.

In brief, Utah International has sufficient coal reserves and water supply which it has dedicated to the project. Pacific Lighting and Texas Eastern will own and operate the processing plant facilities. Pacific Lighting's 50-percent share of the plant's SNG output will be transported to the area served by Pacific Lighting affiliates through existing pipelines. Availability of such a large block of new gas in southern California will be in the national interest both for the volumetric improvement in overall energy supply and in mitigation of air pollution. Texas Eastern's part of the SNG will be used to bolster its western gas system's reserves.

Coal gasification in this projected plant will be accomplished by using the Lurgi process. This method can be described as a fixed-bed, high-pressure, steam-oxygen process that is well suited for gasification of coals that can be, and are being, strip mined from Utah International's leases in the San Juan Basin.

The Lurgi process has been used commercially for years in smaller-scale coal-to-gas plants operating in several countries of the world. The gas produced by the Lurgi gasifiers in the proposed New Mexico plant will be upgraded by catalytic methanation, dehydrated and other-

wise purified to produce a synthetic gas with the physical properties which will allow complete interchange or commingling with natural gas.

The Lurgi process is unique in that it is the only commercially proven gasification reactor currently available, and it is the only process that will permit us to bring this SNG supply increment into reality within the time schedule proposed. The project will be developed with appropriate protection of the ecology of the surrounding area.

I think my colleagues will go a little further into that point. Another attribute of the three-company plan, is that both coal and water are available in volumes that will enable the complex to be expanded in 250 million cubic feet per day—MMcfd—increments to eventually reach an output of 1 billion cubic feet of SNG per day.

This means that the second generation 250 McFD plant can benefit from improvements the first generation Lurgi unit will undoubtedly generate, or utilize more efficient gasifier technology that may become available from one of the several research programs in, or approaching, the pilot plant stage at this time.

That is an example of why Texas Eastern feels that our announcement of this coventure gasification project should not retard research and development directed toward perfecting additional, more efficient coal gasifiers. For, it seems to us that additional coal-to-gas plants utilizing more efficient processes will be absolutely necessary in preventing the energy supply-demand imbalance from perpetuating or enlarging.

At Texas Eastern, we feel that a major role of the Federal Government, is the development of policies that will provide companies in the private sector with the incentives and environment that will enable them to quickly bring all of their resources to bear on promising resolutions of the energy supply problem.

Extremely large amounts of capital investment are required for fast development of both conventional natural gas reserves and supplemental gas projects. New incentives and an improved business climate are needed to attract such investments. The Federal Government might also consider additional funding for recognized research institutions and private sector programs leading to development of advanced coal gasifiers, such as those that will use bituminous coals as feeds for which current Lurgi reactors are not well suited.

Again, Texas Eastern is appreciative of the courtesy the Senators have extended to it by inviting its views to be presented to this Congress, of business and Government working together for common goals. To that, I add my personal thanks, Mr. Chairman and Senators, for your considerate attention.

Thank you, Mr. Chairman.

Senator Moss. Thank you very much, Mr. Ewing. That is a fine statement and we are glad to have you come for Texas Eastern Transmission Corp. I think we will proceed with the other witnesses at the table and then ask questions in any order that the Senators may have. We will hear from Mr. Wilson next.

Mr. WILSON. Mr. Chairman, members of the committee. My name is Alexander M. Wilson. On my left is Albert L. Reeves, vice president of the company. I am president of Utah International, Inc.,

which is principally engaged in mining operations directly, and through subsidiaries and affiliates, in the United States, Canada, Australia, New Zealand, and Peru.

Formerly Utah Construction and Mining Co., our corporate name was changed just last month to Utah International, Inc., partly because of the termination of our construction activities and partly to reflect the expanding scope of our business.

Utah welcomes the committee's invitation to participate in these hearings on the development of cost gasification in the United States. The timing is especially propitious since there are already studies in progress to determine the technical and economic feasibility of producing synthetic gas in commercial quantities from coal and water reserves available to Utah International in northwestern New Mexico.

Since 1957, Utah has held a coal mining leasehold on the Navaho Reservation under an agreement with the Navaho Tribe of Indians. It was enlarged by an amendment in 1965. The area of the leasehold now includes some 31,000 acres of land lying in an irregular and relatively narrow strip extending for approximately 25 miles on a north-south axis.

Our investigations have disclosed that underlying the leasehold is at least 1.1 billion tons of coal which is recoverable by conventional surface mining methods.

This is a sub-bituminous coal. In heat energy, it averages about 9,000 B.t.u.'s to the pound. Because of its low grade, shipment is impractical except for short distances. It must be converted at sites adjacent to the mine into some other form for more efficient distribution as, for example, electricity.

Nevertheless, these reserves comprise one of the largest, and one of the lowest cost, energy sources in the United States. The problem of how to bring it to market was solved in the 1960's by new and comparatively recent developments. All of them involved the economics of scale—larger and more efficient mining and generating equipment, and new techniques of high-voltage, long-distance transmission of electric power.

The first commercial utilization of this coal was, in fact, as fuel for thermal powerplants and resulted in commencing operations at our Navaho mine. Beginning in 1963, Arizona Public Service Co. brought three generating units into operation, based on these reserves.

In a major expansion of the plant, a group of six utilities, both public and private, installed two large additional generating units which were placed in service in 1969 and 1970. As of this time the plant has a total generating capacity of 2,165 MW. It is expected to burn approximately 7.5 million tons of coal in each year of operation at anticipated load factors.

Under existing contracts, 330 million tons of our Navaho reserves have been committed to fulfill the fuel requirements of the Four Corners Plant over a period of 35 years. This term may be extended to 50 years at the option of the utilities; 800 million tons of coal reserves, together with water available under a purchase agreement with the Department of the Interior, are as yet uncommitted.

In October of this year, Utah International, Pacific Lighting Service Co. and Texas Eastern Transmission Corp. signed an agreement

to conduct joint studies of the feasibility of producing synthetic gas from the Navaho coal deposits. The studies are scheduled for completion by July 1, 1972 and Utah has agreed to hold the uncommitted coal and water available until that date.

If the findings of these studies are favorable, Pacific Lighting and Texas Eastern would consider the construction of one, and up to four, gasification plants on a site or sites adjacent to our coal leasehold.

Each such gasification unit would utilize an estimated 7.5 million tons of coal annually. According to our associates in the feasibility studies, each plant would produce 250 million cubic feet of gas daily. Enriched by methanization, the synthetic gas could be either interchanged or mixed with natural gas, having substantially equivalent heat values.

Like natural gas, its utilization would be essentially pollution-free. Distribution would be by a 50-mile feeder pipeline which would connect the gasification plants with existing east-west trunk pipelines near Gallup, N. Mex. Texas Eastern and Pacific Lighting would construct, own, and operate the gasification plant or plants, sharing and marketing the gas produced.

Utah International's role would be that of the miner. We would produce and deliver coal in the range of from 7.5 million to 30 million tons per year, depending on the extent to which the potential of the project was developed. Sufficient coal and water are available to us to support the operation of a four-unit gasification plant, having an aggregate output of as much as 1 billion cubic feet of gas daily, over a period of 25 years.

If the feasibility studies are favorable, and if the project goes forward with the construction and activation of one or more gasification plants, a breakthrough of major significance will have been achieved. It would fulfill many priority objectives. A major source of energy would become available to relieve shortages which are serious and imminent.

Environmental consequences could be controlled in the production of the gas and virtually eliminated in its consumption. It would bring substantial employment and other economic benefits to the hard-pressed Navaho people. Extensive coal reserves elsewhere in the Western United States would also become amenable to gasification and therefore more readily accessible to distant energy markets.

It is with considerable enthusiasm, Mr. Chairman, that we at Utah International have joined with Pacific Lighting and Texas Eastern to conduct these feasibility studies. When they are completed and the results have been analyzed, we hope to be able to report to you that the gasification project is soundly conceived and will be brought into operation with a minimum of delay.

We are aware of the widespread interest in the development of a practical method of coal gasification, especially on the part of the national administration and the Congress. It should have general public approval and acceptance because it can add immensely to available supplies of energy with a minimum effect on the environment.

S. 1846, which Senator Jackson and Senator Moss introduced last May, appears to present a constructive approach to the problem. Its objectives of developing and demonstrating alternative gasification processes would stimulate research into new and increasingly refined

technologies. In the context of the impending energy crisis, it is imperative and multiple initiatives in this vitally important field be encouraged.

We profess no expertise in the science of gasification. But it is encouraging to us that our associates in the present feasibility studies have confidence in the German process developed by Lurgi. It is gratifying, too, that our joint efforts toward achieving its practical application are at our own cost and are not dependent on financial subsidies from the Federal Government.

This does not mean that we shall not need the assistance of this distinguished committee and other committees of the Congress, and of the agencies of the executive branch which have permit and regulatory responsibility. There are many facets to be considered in what is bound to be a very complex development.

This venture is a bold one and expensive in its scope. If it is to succeed, we will need the good counsel and support of all those in the Federal and State governments to whom the availability of this new energy form is a goal to be attained as soon as possible.

It is a privilege to appear before your committee on behalf of Utah International. We appreciate deeply your interest in what we are doing in this field. If the chairman or members of the committee have questions, I shall be pleased to try to answer them.

Senator Moss. Thank you very much, Mr. Wilson, for a fine statement and explanation of the joint program that you are engaged in with Texas Eastern and Pacific Lighting Service. We will now hear from Mr. Harvey Proctor of the Pacific Lighting Service Co.

Mr. PROCTOR. Thank you, Mr. Chairman. I also appreciate the opportunity to appear here today.

As you have indicated, my name is Harvey Proctor. I am president of the two public utility subsidiaries of Pacific Lighting Corp., Southern California Gas Co., and Pacific Lighting Service Co. I have been in the gas business with the Pacific Lighting Co's. for more than 30 years.

Southern California Gas Co. at present serves natural gas to approximately 3 million residential customers on a firm basis. The company also serves about 175,000 commercial buildings and small industries under firm or noninterruptible schedules. About 1,550 of our largest customers are served under interruptible rate schedules and are required to change to standby fuel when necessary to supply the demands of firm customers.

In addition, Southern California Gas Co. supplies gas at wholesale to the City of Long Beach Municipal Gas Department and to San Diego Gas & Electric Co. which serves San Diego County. In total, the company serves natural gas to over 3,175,000 customers in 12 central and southern California counties with a population of over 10 million people.

Our present sources of gas supply consist of contracts with El Paso Natural Gas Co. and Transwestern Pipeline Co. for 1.75 billion cubic feet per day and 750 million cubic feet per day, respectively. In addition, we purchase approximately 300 million cubic feet per day from California sources for a total of approximately 2.8 billion cubic feet per day.

During the last 2 years, we have been unable to contract for additional gas supplies to satisfy the increasing demands of our gas customers. The last authorization for increased supplies to the Pacific Lighting System was made by the Federal Power Commission on March 13, 1970, when the Commission authorized El Paso Natural Gas Co. to increase its deliveries to us by 100 million cubic feet per day beginning on November 1, 1970, and 100 million on November 1, 1971.

Since 1969, neither of our major gas suppliers, El Paso Natural Gas Co. or Transwestern Pipeline Co. has been able to augment their gas reserves to the extent necessary to permit them to contract with us for additional increments of gas supply. In addition, our sources of gas from within the State of California have declined rapidly since 1968, due to rapid depletion from existing sources and a reduction in drilling for new sources. Thus, it has been necessary for us to look to other potential sources of gas to supply the continuing demands of our customers.

I won't take your time to go into detail as to our gas acquisition activities in areas other than coal gas. However, we are convinced that in order to continue to satisfactorily supply the gas energy needs of southern California, we must aggressively seek gas supplies from all available sources. Thus, we are actively involved in projects considering potential gas supplies from South Alaska, the North Continent area, and Latin America.

During 1970, we also started a joint exploration program with Transwestern Pipeline Co. to search for gas in the Southwestern United States to back up that supplier's existing contract to supply us.

This year, we joined Transwestern's parent company, Texas Eastern Transmission Co., and Utah International, Inc., in economic and technical feasibility studies of production of gas from coal reserves in northwestern Mexico. The technology of producing pipeline quality gas from coal is well developed.

The joint research program of the Department of Interior and the American Gas Association should result in substantial improvements in the efficiency of such technology. However, the gas demands of our market simply won't allow us to wait for the results of this research program.

The agreement with Utah International and Texas Eastern provide for studies of the feasibility of the gasification plant and a mining feasibility study, both to be completed by July 1, 1972. Utah has agreed to hold available its coal and water rights which are capable of supporting the production of 1 billion cubic feet per day of synthetic methane for 25 years.

Agreement has been reached to employ Battelle Memorial Institute to study and recommend regarding the possible effects of the plant upon the environment at the plant location.

If the initial studies show the project to be feasible, we expect to file an application with the Federal Power Commission for authority to construct the first plant with a capacity of 250 million cubic feet per day.

The Pacific Lighting Co.'s will continue to support financially the Department of Interior-American Gas Association coal-gasification research project, and, of course, any process improvements made available from the research project will be incorporated in the plant design.

Pacific Lighting will have the right to participate up to 50 percent in ownership of the plant and will own 50 percent of the gas to augment our gas supplies. The remaining 50 percent will augment the supplies of Transwestern Pipeline Co.

Preliminary estimates of the cost of the plant indicate a capital investment of \$200 million for a 250-million-cubic-feet-per-day plant. I should say parenthetically that statement of cost may be on the low side. The statement is in days-dollars and the plant won't be built for sometime.

I would say a better range might be 200 million to 250 million, but related to the 200-million figure, with 75-percent debt financing and 50-percent ownership, this would represent an equity investment for Pacific Lighting of \$25 million. We expect that the plant could be on stream by 1975.

Our entering into this agreement with Texas Eastern Transmission Corp. and Utah International, Inc., is not our first interest in coal gasification. Pacific Lighting has for many years recognized that the significant coal deposits in the western part of the United States constituted energy reserves which might some day be called upon to meet our increasing requirements in southern California.

For this reason, the Pacific Lighting System has contributed financial support through the American Gas Association and other trade groups to the research and development effort to find more economic methods to convert coal into clean-burning gas. We recognize that much more research effort is needed in this area.

In view of our acute supply situation in southern California, however, we felt the need to go ahead with the established processes available today. We are convinced that these proven processes will enable us to commence operation on the first phase of what we hope will be ultimately a 1 million cubic feet per day project.

As additional research and development is undertaken and as we obtain experience from the first phase of the contemplated project, we envision that subsequent phases and projects will be refined and modified to incorporate the best technology then available. We feel strongly that the experience gained from the operation of this first plant will help our project, and other groups, to improve the design and efficiency of subsequent coal gasification plants.

Our being a participant in this project in no way will diminish our interest or continuing support for the joint Department of Interior-American Gas Association coal gasification research projects. We recognize the need for further research and development in this area and have agreed to financially support the joint Interior Department-AGA research work. However, in the meantime, through our contemplated project, we will have helped to meet the increasing energy demands of the customers we serve.

Mr. Chairman, I appreciate very much this opportunity of presenting Pacific Lighting's plans in this very vital area of energy supply.

Senator Moss. Thank you, Mr. Proctor, for that statement and for your assurance that you continue to support the AGA cooperative program in research with the Department of Interior.

Is it your view that the corporation proposed by S. 1846 can be helpful in getting on with the demonstration plant at an earlier time?

Mr. PROCTOR. Senator, my feeling is as earlier expressed, that it is going to take a good deal of cooperation between Government and industry to come up with the most efficient method of converting coal into gas. I guess my analysis would be that a corporation to build a demonstration plant, may be somewhat premature.

An orderly sequence to me would be to continue the proposed "AGA-Department of the Interior" project far enough to be able to select the one or two systems that offer substantial improvement over the Lurgi process. At that point, then I think the Government might very well consider building a plant. But at this point, I frankly don't think the research is developed far enough and I also feel that the efforts by ourselves and by El Paso will very likely result in demonstrating the commercial feasibility of coal gasification without a Government plant.

Senator Moss. So you think there is some peril that the corporation might prematurely begin a demonstration plant before there has been adequate time to choose among different pilot plants that might be developed by the joint companies and by individual efforts being made, such as your group of companies and El Paso?

Mr. PROCTOR. Yes; as I understand the proposal under the bill, it would appropriate dollars immediately and it would require the corporation to dissolve and dispose of its assets at the end of 6 years. I guess what I am really saying is that I don't think the research program will move fast enough to allow a plant to be built within that framework.

I think it would be more appropriate to consider a large-scale plant to demonstrate the research output of the AGA department project, maybe 4 years from now, something on that order.

Senator Moss. Do you think the amount of money that is programmed, this \$30 million a year, is adequate or will it take more than that?

Mr. PROCTOR. At the moment, I believe it is adequate. We have looked at this very carefully and as I mention in my statement, we have been very prominent in coal gasification work at "IGT." I believe this is as far as the research work can progress over the next 4 years.

What comes beyond the 4 years, I am not able to say.

Senator Moss. You state that you expect to file an application with the Federal Power Commission for authority to construct the first plant. Other than granting permission, does FPC have any other authority or involvement?

Mr. PROCTOR. We believe this to be a jurisdictional plant as far as FPC is concerned. We expect to acquire a certificate from the Commission and we expect the plant to be regulated as a national gas plant, under the National Gas Act.

Senator Moss. You are speaking of the increasing demands. Do you have any plans to supplement your gas supply with liquified national gas from Alaska, for example?

Senator PROCTOR. Yes, we have. We are looking at south Alaska. This area is the one in which the economics almost dictate if the gas is to come out of south Alaska, it must come out in the form of "LNG". We are negotiating currently with the producers in that area for gas is to come out of south Alaska, it must come out in the form of LNG.

We are also looking, and this is farther down the road, to availability of gas in Latin America which I also mentioned in my statement. This would be ING.

Senator Moss. Mr. Ewing, what is the estimated cost of the gas to be produced by this Lurgi method?

Mr. EWING. Well, again this is the purpose of the feasibility study, the intense study that we have coming up. It is like Mr. Proctor said, the range of cost is 1972, 1973, 1974, and 1975 when this plant would be built would probably be more toward \$250 million than \$200 million. Just a round number, I would say, would be something in the order of \$1 per MCF, but it could be less than it could be slightly more.

Senator Moss. And that, of course, is much higher than the cost of natural gas at the present time?

Mr. EWING. Yes, sir.

Senator Moss. How much higher?

Mr. EWING. Very much higher.

Senator Moss. Out in the Four Corners area, what is the wellhead cost of natural gas now?

Mr. EWING. Well, it is undergoing final determination, but it is in the order of 28 cents, I believe.

Mr. PROCTOR. Yes, on that order. I think perhaps a more appropriate price comparison might be the cost of gas in the pipeline in that area, which would be somewhat higher. That is wellhead, plus gathering, plus transport to within 600 miles of market, but even that figure is substantially lower than a dollar, something on the order of 35 cents.

Senator Moss. I see. Are there any other regulatory commissions other than Federal Power Commission which you will have to clear before you go ahead with building of the plant?

Mr. EWING. Through the Federal Power Commission, of course. We will be working with EPA and other environmental agencies and I must say, all of these through the "FPC" application. They require exhibits and information and the environmental impact study that is shown on the study.

We will also be working with the local authorities in that area.

Mr. PROCTOR. Mr. Chairman, might I add a comment?

Senator Moss. Yes.

Mr. PROCTOR. I want to add on the record that Pacific Lighting Companies are regulated, of course, by the California Public Utilities Commission and we can anticipate their being involved in some fashion, at least, in approving the price of this gas.

So we would anticipate they would be involved in the regulatory process.

Senator Moss. I see. Would you expect, as El Paso testified, that this gas would be blended in with natural gas running already through the line and therefore, the price be affected by the blending?

Mr. PROCTOR. I think Mr. Ewing might be able to answer that.

Mr. EWING. I got the feeling from the El Paso testimony that this possibly would be a major situation in case they could not develop this methanation step. They would then blend low B.t.u. gas with their high B.t.u. gas and come out with a composite that was acceptable.

We do not take this position. We are confident that we can develop the methanation step to get the B.t.u. up very close to 1,000, something in the order of 950; that the gas will have physical properties that are completely compatible with the natural gas and could be interchanged with or blended with, to have gas that is suitable for the Western market.

Mr. PROCTOR. I might say, I share this view.

Senator Moss. Thank you, Mr. Wilson, you are of course, mining coal now in the surface mining method for the Four Corners plant. Would this operation be essentially the same in getting the coal out?

Mr. WILSON. Yes; it would, Mr. Chairman, essentially the same.

Senator Moss. Are you having any problems with restoration of the surface after the coal is extracted?

Mr. WILSON. We have a restoration activity underway, Mr. Chairman. We move the ash from the powerplants to the mine site under a contract entered into with the utility companies with the approval of the Secretary of the Interior. That ash is placed in the valleys, the disturbed earth is moved on top of the ash. This results in a recontouring of the surface of the mined area into a surface that is compatible with the existing terrain.

Now, about 30 percent of the total mined area would be utilized for the placement of ash. We would intend that the remainder of the 70 percent of the surface would be treated in the same fashion and we would plan to carry on that activity into the disturbed surface as a result of this.

Senator Moss. Do you employ a number of Indians? What percentage of Indians do you employ, working in the mine?

Mr. WILSON. Of our total force of some 340 people, about 60 percent are Navaho Indians. These Navahos are employed in areas ranging from our administrative and supervisory forces, down into the hourly paid employees of the mine.

Senator Moss. And would your percentage remain that high?

Mr. WILSON. Yes; we would expect the percentage to be maintained.

Senator Moss. Do you have to pay local taxes to the county and to the State of New Mexico in addition to your royalties?

Mr. WILSON. Yes; we do, Mr. Chairman. We expect to pay this year, some \$600,000 in taxes to the State of New Mexico, even though our facilities are located in the Indian reservation.

Senator Moss. Thank you, gentlemen. Senator Jordan has gone to answer the roll and I must go. He will be back before I get back, I would expect any minute. I would appreciate it if you would wait for Senator Jordan and if he has any questions respond to him and then we will move on to the additional witnesses. Thank you very much. We will be in recess temporarily.

(Recess.)

Senator JORDAN (presiding). Please come to order. I have no questions of the panel. Do you have any questions, Senator?

Senator FANNIN. No questions at this time, Mr. Chairman.

Senator JORDAN. Thank you, gentlemen.

Mr. WILSON. Thank you.

Mr. EWING. Thank you, sir.

Mr. JORDAN. Before I call the next witness, Senator Hansen would like to submit a question to Mr. Walsh in writing and ask that the question and reply be in the record. He will write to you, Mr. Walsh, and submit his question in writing. He is not here.

Mr. WALSH. Yes; Senator, we will be glad to respond to that.

(Question submitted by Senator Hansen and response by Mr. Walsh may be found in the appendix.)

Senator JORDAN. All right. Thank you very much, you will be hearing from Senator Hansen.

Senator JORDAN. The next witness is Sherman K. Reed, Director, Central Research Department, FMC Corporation.

STATEMENT OF SHERMAN K. REED, DIRECTOR, CENTRAL
RESEARCH DEPARTMENT, FMC CORPORATION

Mr. REED. Thank you, Mr. Chairman.

I am Sherman K. Reed, and I am representing the FMC Corp. I am Director of the Central Research Department.

I have submitted to the committee, as you gentlemen know, a statement in response to a letter from Senator Jackson regarding information of FMC Corporation's plans for its process for manufacture of synthetic crude oil and pipeline gas from coal. I can either summarize that statement and answer questions or answer questions directly, if you wish.

Senator JORDAN. Go ahead with your statement. It doesn't appear to be very long and maybe some questions will come to us as you go through it.

Mr. REED. All right.

Mr. Chairman and Senators, the following statement has been prepared in response to your request for additional information on the announcement by FMC Corporation of plans for its process for manufacture of synthetic crude oil and pipeline gas from coal.

FMC is a diversified corporation with major activities in machinery, chemicals, films and fibers, and ordnance. Its 1970 gross sales were in excess of \$1.3 billion; sales in the chemical area were \$289 million.

FMC Corporation is well known for its contributions to governmental needs through research, development, and production of ordnance and machinery equipment. Some of our products have also attained major use as energy producers for the military and space efforts.

Early in the 1950's, FMC became interested in the production of metallurgical coke from coals. This interest was caused by shortages of coke for our elemental phosphorus production facilities in Idaho. As a result, FMC developed a multistage, fluidized-bed pyrolysis process for the production of high grade metallurgical coke from normally noncoking coal available nearby, and it now operates a plant with a feed capacity of 600 tons of coal per day for its own use. The process is available to others on a royalty basis.

For this and other coal-related work, FMC Corporation has invested more than \$20 million, developing substantial proprietary technology relevant to gas and oil manufacture from coal.

In 1962 we were approached by the newly formed Office of Coal Research to determine if our technology could be adapted to the processing of coal to make products which have greater utility and which would increase the value of the coal. The resulting project, under contract to the Office of Coal Research, was known as Project COED, an acronym for Char, Oil, Energy Development.

Basically, the process consists of multistage, fluidized bed processing of coal to produce a crude oil, a low B.t.u. gas, and char. The crude oil is hydrogenated to make a valuable synthetic crude oil, suitable for refinery processing, and containing no sulfur and no residium. The gas would be used for the production of hydrogen for oil hydro-treating, and the char would be sold as a fuel or as a feed stock for other processes.

The results of the research and development work were so encouraging that the Office of Coal Research authorized the design and construction of a large pilot plant at the FMC facilities in Princeton,

N.J. The pilot plant is now operating in a completely integrated fashion, and results are being obtained necessary for the final design of a full scale commercial plant.

The plant, and the successful development effort preceding it, are concrete evidence of the excellent cooperation, encouragement and guidance provided by George Fumich, director of the Office of Coal Research and his technical staff, particularly Messrs. Neal Cochran, Paul Towson, and George Staber. We expect that this encouragement will continue, and it will be necessary if the broad capabilities of Project COED are to be realized.

Thus, FMC has used its experience in the multistage, fluidized bed processing of coal for the development of COED, and for the production of coke. It now envisions a further use of this kind of processing for the project we are here to discuss.

The COGAS process represents FMC's approach to utilizing a multistage pyrolysis process concept as a first step in the production of substantial quantities of pipeline gas as well as synthetic crude oil. In this concept the product char from multistage pyrolysis is gasified by reaction with steam, using FMC proprietary process developments. The synthesis gas produced is then combined with the off-gas from the pyrolysis.

Both gases, rich in hydrogen and carbon monoxide, are purified and converted to the high methane content of pipeline gas by modified-conventional processes. This gas is that which has been discussed today as 950 to 1,000 B.t.u.'s.

Purification processes remove essentially all the sulfur from the products and yield elemental sulfur and aqueous ammonia as by products. The ash content of the coal is a waste product like powerplant fly ash, and will be disposed of as land fill or as a fill in abandoned portions of the mine. No waste products harmful to the ecology are produced.

Economics realized by the COGAS process result from use of large-scale fluidized bed processes, air instead of oxygen, low-pressure operation, high char reactivity with steam, and production of a valuable syncrude oil as coproduct.

The COGAS program will develop the design of a commercial plant to produce 250 MM SCFD of pipeline gas and 24,000 barrels per day of synthetic crude oil. Several critical parts of the process will be piloted. Our confidence in our ability to achieve early construction of such a plant is based on the already demonstrated success of the FMC coke production plant, our proprietary know-how, the OCR-funded COED pilot plant, the emphasis on maximum use of standard equipment, and our own process.

Bechtel Corp. has worked with FMC in developing a preliminary commercial plant design and a cost estimate of considerable depth and accuracy which is the basis for our belief that the plant can be built and operated profitably.

The fixed capital required for a COGAS plant to produce 250 MM SCFD of pipeline gas and about 24,000 barrels per day of synthetic crude oil from Midwestern coal is estimated to be \$250 million escalated to 1976, the year of planned completion. By that, I mean when the plant is built and if it is completed late in the year 1976, the cost in then dollars will be \$250 million.

The cost of the associated underground mines with annual capacity of 8 million tons is an estimated additional \$50 million. Based on these capital requirements and the estimated operating costs, the COGAS process should yield an average 20-year price of 75-90 cents per million B.t.u. for the first plant completed in 1976 with the oil priced at \$4 per barrel. We believe this is a realistic value at that time for the oil.

The COGAS project program—FMC is organizing a consortium of major companies in the energy field to fund and carry out the development program. As now visualized, this development consortium will own the FMC gasification inventions and technology now available and that developed as the program proceeds. An objective of this company is to develop the potential for selling technology and know-how by licensing arrangements to others who will build the commercial COGAS plants.

Development funds will cover supporting pilot and laboratory studies, further engineering and process studies, and identification of suitable coal properties. To achieve a schedule to permit completion of a plant, under optimum conditions in mid-1976, a number of elements which might normally be sequential in a program of this type will be overlapped as much as is considered wise and practical. When the decision is made to start detailed engineering of a commercial plant, the capital expenditure will be handled separately by the group formed to build the plant.

We would expect that some of the partners in the COGAS Development Company will be interested in proceeding with the first commercial plant. By proceeding with this plant under a consortium ownership, technology developed in the design and construction of the first commercial plant would add to the value of the technology owned by the development company.

In addition, we believe that private financing would be more readily attainable. The nature of the crisis situation in natural gas supplies makes it imperative to achieve a program schedule such as we have proposed for use of domestic raw coal as a source of supplemental gas.

Since the COGAS plant is designed to produce pipeline gas and synthetic crude oil from coal, our candidates for formation of the consortium have been drawn from the leading companies in the natural gas transmission, petroleum and coal mining industries. A strong interest has been found from several major companies and formation of a development consortium is expected to be accomplished in the next few months.

Our experience, over many decades of development, design, construction, and operation of well-planned chemical plants has shown that investment in first plants of a kind involve substantially more risks than subsequent plants. Once a plant is operating and generating profits, future plants can be built and operated on a relatively routine basis.

The COGAS plant to be engineered will make maximum use of standard and well-developed technology to the extent available. However, for a first plant, a \$300 million investment will either require a very high potential for profit for the risk to be assumed, or will require other guarantees.

Of course, in that \$300 million I was including the cost of opening the mine that I mentioned.

It seems clear to us that if the impending gas shortages are to be eliminated in a reasonable and acceptable time frame, the Government should do all it can to encourage the development of processes and erection of plants. Several private processes have been announced recently which might help avert such shortages.

The Government can materially aid in these developments by creating a climate in which private companies can use their technology, preserve their proprietary rights, and secure financing on a reasonable basis. Government guarantees for low-interest loans as done in the international sector would be one constructive way to diminish risk for a first plant.

The effect of interest rates on estimated gas prices is significant because the process is capital intensive and the economics are based on borrowing a majority of the capital required. For example, in one case we estimated an average gas price of 82 cents per 1,000 cubic feet using an interest rate of 11 percent. If the interest rate could be reduced to 7 percent, the average price for the same rate of return on equity would then be 70 cents per 1,000 cubic feet. A Government-guaranteed load provides three benefits: one, lower cost to the consumer; two, lower risk for the investor; and three, no capital investment by the Government.

It also seems appropriate for the Government to continue vigorous research on coal gasification, particularly in those elements where innovation is most needed. We believe that, given the presence of developed technology, industry, with suitable Government encouragement, will rise to the challenge and will build the plants.

We, therefore, feel that the Government's proper role is to provide technology through contracting for research with private industry in fields where additional knowledge is needed to meet Government objectives and to stimulate the erection and operation of plants supplied by industry. This stimulation can be accomplished by Government guaranteed loans or other incentives which preserve the present synergism of the financial community and the gas pipeline and the gas distribution industries.

Senator JORDAN. Thank you, Mr. Reed, for a good statement.

It is very interesting what you are doing in your coal gasification project. In the process, can you tell us any more about it other than the proprietary process? Is it similar to anything other people are doing?

Mr. REED. Well, all gas processes have a number of similarities and that is in a sense that coal or char or some carbon containing material is heated to an elevated temperature and then treated with steam and under these circumstances carbon monoxide and hydrogen, possibly along with some methane is formed, and this mixture of gases has to be converted to methane.

Ours does the same thing, but ours differs in several respects. One of these is we start with coal and we try to obtain from it oil which it turns out can be formed very readily and is valuable. The economics are better by taking off this oil which is a needed energy source and it is sulfur-free, by taking this out first. Then the remaining char which is not capable to given value to oil is converted to this mixture of gas. The mixture of gases can be cleaned up to remove sulfur and processed to pipeline quality.

Our process does not use water. It does use air and makes simpler the control of pollution, because the amount of off gases is very small and can be readily treated.

Senator JORDAN. We would like to know a little bit more about your pilot plant and how long you have been working on the process? What is the approximate size of your experimental plant? Do you operate it on a continuous basis? How much have you spent in research? Tell us what you can about it.

Mr. REED. The process is made up of a number of elements. Of course, as I told you, one of the things that will be built into the plant is project COED, and this has been going on under Government sponsorship for a number of years.

We would not plan, in the case of our process, to have a completely integrated pilot plant for conversion of coal all the way to pipeline gas. Instead, we would take the segments which have not been operated on a large scale and operate these segments to prove the segments of the plant. It turns out that the specific unit where the gasification is accomplished is very parallel to a unit that is operated for other purposes than we have available to us.

We will be able to operate this unit at a scale of several tons an hour of feed and operate it as a pilot plant within the first 6 months of the funding of the program which we anticipate will be next year. So that by the end of the next year the gasification will be thoroughly piloted at a scale of several tons of char feed per hour, which is a very substantial scale and in our judgment is adequate for building a big plant.

There are many other units in the plant such as gas purification. What we have done in these instances is to locate throughout the world where such units are operating on similar feeds and we feel that for most of the other segments except the methanation segment of the plant, we will be able to get data from present operating units that will allow the design of a large plant.

In the instance of methanation, we are constructing as a part of this a pilot plant which also will be completed late next year which will be of similar size. That is, the equivalent of several tons per hour char feed at the beginning which will independently demonstrate the effectiveness of the methanation process.

So, in summary, we will not have an integrated pilot plant of these segments of the process within next year, and the following year so we can have adequate data to build our plant.

It is our judgment that this is all that will be required to design a plant.

Senator JORDAN. Thank you, sir.

Senator FANNIN?

Senator FANNIN. Thank you, Mr. Chairman.

Mr. REED, this certainly is of great interest. I am just wondering if you feel this has a greater potential than the Lurgi or the other processes which we have talked about today? Do you feel this has a feasibility that has not been brought out in the other projects?

Mr. REED. Well, to answer, first, about the Lurgi process, of course the Lurgi process is an operating process that has been proven. However, all the information we have on the Lurgi process shows it to be a

more extensive process than our process, more than many of the other processes in the OCR-AGA combined program.

Further, the Lurgi process uses what some call a consist which is a coal with larger particles. It is not suitable to use just plain ground coal so there has to be some compacting and this increases the cost associated with it. But it is an operating process and it does represent a way of proceeding.

We feel the advantages we have are economic in comparison with that. Also, in ours we can use a greater variety of coal.

Now, the comparison of our process with all the other processes that we know about is difficult for FMC because it is hard for us to be an expert on other people's technology. However, we have confidence what we are talking about can be developed and can give the kind of economics that we talk about on the schedule that is indicated in this report, and if these things come about, we have found that the members of the energy business we have talked with consider them to be of very great interest in comparison to anything they know about.

Senator FANNIN. I was wondering if the coal that is available in the Four Corners area—I imagine you are familiar with that coal?

Mr. REED. Yes, sir.

Senator FANNIN. Is that the type of coal that could be readily used for your process?

Mr. REED. Yes; the coals available there are suitable. The coals that are suitable are coals that—western coals and midwestern coals, bituminous coals generally are suitable for the process.

One coal differs from another in terms of economics of the process because some coals inherently rate more oil than others and oil is a valuable byproduct and the more oil that is generated by specific coal, the better the economics turn out to be.

Senator FANNIN. That is what I was wondering. In other words, if you take a ton of coal, would your process develop as much gas as the other processes?

Mr. REED. Yes, sir. In general it wouldn't give quite as much gas as the others, and the reason for that is that we get this coproduct, oil. So, if you look at it from an energy basis, and I can only give a specific example, this wouldn't be exactly true for each coal, but if you put in a ton of coal, in the neighborhood of 80 percent of the energy would be recovered as valuable products, and a third of this energy might come out as oil and two-thirds gas.

Now, from another process that makes only gas, why a bigger percentage of the energy could come out directly as gas. However, this is a penalty in terms of the overall economics.

Senator FANNIN. All of these processes are quite high in costs when you start talking about 75 to 90 cents per million b.t.u.'s. You are talking about the natural gas coming out of the ground.

Mr. REED. Absolutely.

Senator FANNIN. So, there is a tremendous difference.

Well, thank you very much.

Senator JORDAN. I have just one more question.

I understood you to say you think you can prove your gasification process in 2 years. Why do you suppose the AGA departmental program is going to take at least 4 years?

Mr. REED. Well, I am not really an expert on their program, and the scheduling of their program. I do know that the schedule that we have

talked about represents the best thinking of FMC and the Bechtel organization. It represents an integrated program where we can use the decisionmaking and move along with one program overlaying another to try to achieve maximum rate of progress.

However, I wouldn't want anything I said in any way to degrade your evaluation of the AGA-Government effort because my observation has been these people proceed in a very competent fashion.

So, we have arrived at our schedules by different routes.

Senator JORDAN. OK, thank you very much for your statement.

Now, Mr. David T. Strieff.

**STATEMENT OF DAVID T. STRIEFF, SENIOR VICE PRESIDENT OF
NORTHERN ILLINOIS GAS CO.**

Mr. STRIEFF. Mr. Chairman, I appreciate very much the opportunity to be here today and explain to you the purpose of the coal gasification group as it relates to Senate bill S. 1846.

My name is David T. Strieff. I am senior vice president—technical services for Northern Illinois Gas Co., and chairman of the advisory board of the coal gasification group, a nonprofit effort by seven Illinois gas and electric utilities to investigate the use of Illinois vast coal reserves as a source for a clean-burning, sulfur-free fuel.

I appreciate the opportunity to explain to you today the purpose of the coal gasification group as it relates to Senate bill S. 1846.

Gentlemen, we are all aware of the acute energy crisis facing this Nation today. In Illinois alone last year about 75 billion kilowatt hours of electricity and 10.5 billion therms of natural gas were required to meet the State's energy needs. In a 1-year period—from 1969 to 1970—electricity sales increased by 5.3 percent and gas sales by 8.4 percent.

While the total energy requirements in Illinois and throughout the Nation are skyrocketing, the burden to supply those energy needs falls on a clean-burning, efficient fuel. Today that fuel is natural gas. During 1970 the city of Chicago adopted a pollution control ordinance prohibiting the use of high-sulfur coal as a fuel source in that city. Other communities have followed suit with similar ordinances, and State pollution control measures are expected to become more stringent in the future.

Illinois' natural gas distribution companies have been hard pressed to meet the energy requirements. All of the major gas utilities have had to institute some restrictions—whether they be priority systems or additional load limitations—on their customers.

In light of the critical shortage of natural gas in Illinois and because the State has substantial coal reserves within its boundaries, the Illinois Commerce Commission requested utilities to research the development of coal gasification as a supplemental fuel source for the State.

Thus, the nonprofit coal gasification group was formed and approved by Illinois Commerce Commission in July of this year. The participating companies are: Central Illinois Light Co., Central Illinois Public Service Co., Commonwealth Edison Co., Illinois Power Co., Iowa-Illinois Gas & Electric, Northern Illinois Gas Co. and the Peoples Gas System. These companies serve about 90 percent of the State's gas and electric customers, including more than 3.4 million electric and 2.8 million gas customers.

The purpose of the coal gasification group is to do joint applied research and investigation toward developing an economically feasible coal gasification plant.

How does CGG relate to the Interior Department-American Gas Association agreement for the joint funding of a coal gasification research program? The two programs complement each other, and CGG companies that are AGA members are committing more than \$1 million for the first year of the Interior Department-AGA project.

While the Interior Department-AGA program is on a national level and has as its goal a pilot plant in 4 years with a demonstration plant to follow, CGG is a State-level effort whose purpose is to make use of Illinois resources. Illinois leads the Nation in high-sulfur bituminous coal reserves, which are estimated at 140 billion tons.

CGG will define: the usefulness of coal gas production to Illinois utilities, various processes, environmental and legal aspects, potential plant sites and possible methods of organizing, financing, and operating coal gasification.

Both programs—the CGG on a State level and the Interior Department-AGA project on a national level—are preliminary steps to develop a vital energy source.

The CGG companies agree with the American Gas Association that S. 1846 should draw upon but not duplicate the Interior Department-AGA pilot and demonstration plants. It should benefit from the work of the Interior Department-AGA program.

Utilizing these results, bringing together the Nation's technology and know-how, and offering the necessary financial and organizational posture, a Government-industry coal gasification development corporation to construct and operate a full-scale, commercial-sized plant would be a practical means to get the job done.

Northern Illinois Gas Co., and the six other coal gasification group members endorse S. 1846 with the amendments proposed by the American Gas Association.

Senator JORDAN. Thank you for a good statement.

How far are you along with your research with the program that you are going to do under this consortium of the coal gasification group?

Mr. STRIEFF. As I mentioned in my statement, the group was formerly approved by the Illinois State Commerce Commission 4 years ago and we organized a number of task groups from the member companies to explore and examine all of the various aspects of this program.

Several of the companies have individual members that are participating as advisers on the AGA project that is now in process.

Senator JORDAN. In your opinion, the work of your group will complement the work of AGA and Interior?

Mr. STRIEFF. Yes sir; we feel there are some very unique problems that need specialized investigation.

Senator JORDAN. Thank you, sir. Are there other further witnesses?

The record will be kept open for 2 weeks for any further testimony that might develop. We stand in recess.

(Whereupon, at 3:10 p.m. the committee adjourned subject to the call of the Chair.)

APPENDIX

(Under authority previously granted, the following communications were ordered printed:)

QUESTIONS BY SENATOR JENNINGS RANDOLPH TO THE DEPARTMENT

Senator Randolph. As I mentioned in my introductory remarks, I am concerned about the effects of the price of coal in the cost of producing pipeline quality gas from coal. Mr. Fumich, will you please explain for me whether the cost of coal is a major factor in the cost of developing pipeline quality gas from coal, and if it is, do you have any estimate of how this will affect the price? Could you give me an example, for instance, of what the cost of 1,000 cubic feet of gas would be from a ton of coal at a certain price so that this can be understood by the layman? Also, I would appreciate it if you could explain to me how an increase in the cost of coal would affect the price of this amount of gas.

Mr. Fumich. Yes, Senator Randolph. We believe that pipeline quality gas can be made to sell for 75¢ per MCF from coal costing 25¢ per million B.t.u.'s. Twenty five cents per million is about \$6.50 to \$6.75 per ton for high-volatile bituminous coal and, of course, this figure would vary depending on other factors, including the type of process used, the size of the plant, the location, etc. The price of this gas will be very sensitive to coal prices. To give you a better idea of how an increase in the cost of coal would cause an increase in the cost of gas, an increase in the price of bituminous coal of \$1 per ton is estimated to increase the price of gas 5¢ to 7¢ per million B.t.u.'s.

AGREEMENT BETWEEN THE U.S. DEPARTMENT OF THE INTERIOR AND THE AMERICAN GAS ASSOCIATION FOR THE COOPERATIVE COAL GASIFICATION RESEARCH PROGRAM

This agreement is entered into this 3rd day of August, 1971, between the United States of America, acting through the Department of the Interior, hereinafter called the "Government," and the American Gas Association, a Delaware nonstock, nonprofit corporation with its principal offices located in Arlington, Va., hereinafter called "A.G.A."

President Nixon in a message to Congress on June 4, 1971, outlined a cooperative Government-industry program of coal gasification research. The Government and A.G.A. are desirous of entering into an agreement for the creation, organization, joint operation and mutual funding of an accelerated program of coal gasification research for the first phase of the program through the pilot plant stage, hereinafter called the "program." The program shall be funded through Government appropriations and contributions by industry.

Therefore, the parties agree as follows:

ARTICLE I—AUTHORITY

A. This Agreement is entered into pursuant to the Act of July 7, 1960 (74 Stat. 336; 30 U.S.C. §§ 661-668) relating to coal research and development.

B. A.G.A. is authorized to enter into this Agreement pursuant to Article XIV of its Bylaws and the resolution of the Executive Committee of its Board of Directors at a meeting held June 23, 1971.

ARTICLE II—OPERATING ORGANIZATION

The operating organization of the program shall be as described in the organizational chart which is attached as Appendix A and made a part hereof.

B. Steering Committee

The Steering Committee shall be composed of the Assistant Secretary, Mineral Resources; President, National Academy of Engineering; and the President, A.G.A. The Steering Committee shall resolve matters requiring the mutual agreement of the Program Directors where the Directors cannot agree. Decisions of the Steering Committee shall be final.

C. Program Directors

There shall be two Program Directors: the Director of Coal Research, Department of the Interior; and the Director of Research and Engineering, A.G.A. It shall be the function of the Program Directors to direct and administer the program. This shall include, but not necessarily be limited to, preparation of annual program and budget; solicitation of proposals; preparation of contractor work statements; selection of contractors; approval of contracts; allocation of funds; establishment, organization and direction of operations of the Operating Committee in accordance with the guidelines set out in section D of this Article II, and selection and direction of the technical evaluation contractors described in section E of this Article II.

The Program Directors shall within sixty days after the date of this Agreement prepare rules and guidelines for the conduct and administration of the program which shall be in accordance with this Agreement and which may be altered or amended as agreed by the Program Directors.

D. Operating Committee

The Operating Committee shall be composed of not more than five members who shall be appointed by the Program Directors and who shall serve at the pleasure of the Program Directors. It shall be the function of the Operating Committee to:

1. Review, monitor, and report on a continuing basis all contract research activity; and
2. Review matters, make studies and recommendations, and prepare special reports as may be requested by the Program Directors.

E. Technical Evaluation Contracts

One or more technical evaluation contractors may be selected by the Program Directors to provide in-depth evaluations and reviews of proposed projects, proposals for research project contracts, and work under research project contracts. Each such contractor shall function pursuant to the terms of a contract separate from the research project contracts and shall exercise competent and objective, technical, and engineering judgment.

F. Advisory Committees to the Program Directors

The Office of Coal Research General Technical Advisory Committee (GTAC) will be available to provide advisory assistance to the Director of Coal Research and the A.G.A. Research and Development Executive Committee (Redex) will be available to provide advisory assistance to the A.G.A. Director of Research and Engineering.

ARTICLE III—CONTRACTS

A. All research project contracts and technical evaluation contracts, except as provided in section B of this Article III, shall be prepared and awarded in accordance with Federal laws and regulations, all applicable rules and requirements of the Department of the Interior, and section C of Article II. The Director of Coal Research shall be designated as the contracting officer in all such contracts, and after a contract is executed, he alone shall make all decisions under and relating to each contract, and such decisions shall be final.

B. In extraordinary situations, the Program Directors may authorize individual projects, including the technical evaluation of projects, to be contracted solely by A.G.A. Such contracts shall obligate A.G.A. alone, shall be funded entirely from A.G.G. funds, and shall not obligate the Government: *Provided, however,* That A.G.A. shall be allowed a credit against its one-third share of the program for the costs under such contracts as approved by the Program Directors in accordance with Congressional appropriations. Any such contract or sub-contract, except those for work performed outside the United States by employees who were not recruited within the United States, shall contain the equal opportunity clause set forth in section 60-1.4 of Title 41 of the Code of Federal

Regulations (41 CFR § 60-1.4). Subpart 1-3.8 of Chapter 1 of Title 41 of the Federal Procurement Regulations (41 CFR Subpart 1-3.8) shall apply to all negotiated contracts except when awarded to foreign contractors.

C. All contracts executed under this Agreement shall include a statement that the contract is made under a program in which the Government and A.G.A. are participating.

D. A.G.A. may elect to participate in the negotiation of and shall approve all contracts referred to in section A of this Article III and shall be entitled to receive promptly copies of all financial data, correspondence, reports, etc. provided to the Government. The Government shall have the same rights with respect to the A.G.A. contracts referred to in section B of this Article III.

E. All proprietary information or other proprietary data obtained under this Agreement in confidence either by the Government or A.G.A. during contract negotiations shall be held administratively confidential and shall not be divulged intentionally to third parties without the advance approval of the owner of such information and data unless such information and data are generally available to the public or have been made available to the Government or A.G.A. from other sources without restrictions as to confidentiality or previously used or divulged by the contractor without limitation as to use.

ARTICLE IV—FUNDING OF CONTRACT COSTS

A. Government funding for the program shall be as appropriated each fiscal year by the Congress of the United States specifically for the program: *Provided, however,* That the Government shall not be obligated under this Agreement unless and until funds are so appropriated.

B. A.G.A. funding for the program shall be fifty percent (50%) of the amount appropriated by Congress for the program: *Provided, however,* That A.G.A. shall not be obligated under this Agreement unless and until funds are received from its contributors. Should A.G.A. fail to provide its full fifty percent (50%) share, any commitment by the Government shall be proportionally reduced.

ARTICLE V—PATENTS

Worldwide title to all inventions conceived or first actually reduced to practice in the course of or under any research project contract executed under this Agreement shall be in the Government: *Provided, however,* That the Government with the concurrence of A.G.A. may waive foreign rights in favor of the project contractor. A.G.A. shall receive a royalty-free, irrevocable and nonexclusive license, with the right to sublicense, under said inventions.

ARTICLE VI—DATA

All data generated under any contract executed under this Agreement shall be furnished to the parties hereto, shall not be copyrighted, and the parties shall have the right to publish, reproduce and use said data for any and all purposes.

ARTICLE VII—OFFICIALS NOT TO BENEFIT

No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

ARTICLE VIII—TERMINATION

Either party may terminate this Agreement at any time upon thirty days' written notice to the other party. Upon termination or expiration of his Agreement pursuant to this Article, each party hereto may terminate any contracts in which it has entered under this Agreement: *Provided, however,* That if either or both parties elects not to terminate and to continue any one or more of the contracts referred to in section A of Article III, the party not continuing shall be relieved of all liability for any charges accruing on or after the thirty-first day after delivery of the notice provided for herein with respect to each such contract. In the event of either continuation or termination of any contract entered into pursuant to this Agreement, any reasonable costs or liabilities which

may subsequently accrue as a result of contract performance prior to said thirty-first day after the delivery of the notice provided for herein shall be borne proportionally by the Government and A.G.A. to maintain the ratio of two-thirds to one-third, respectively.

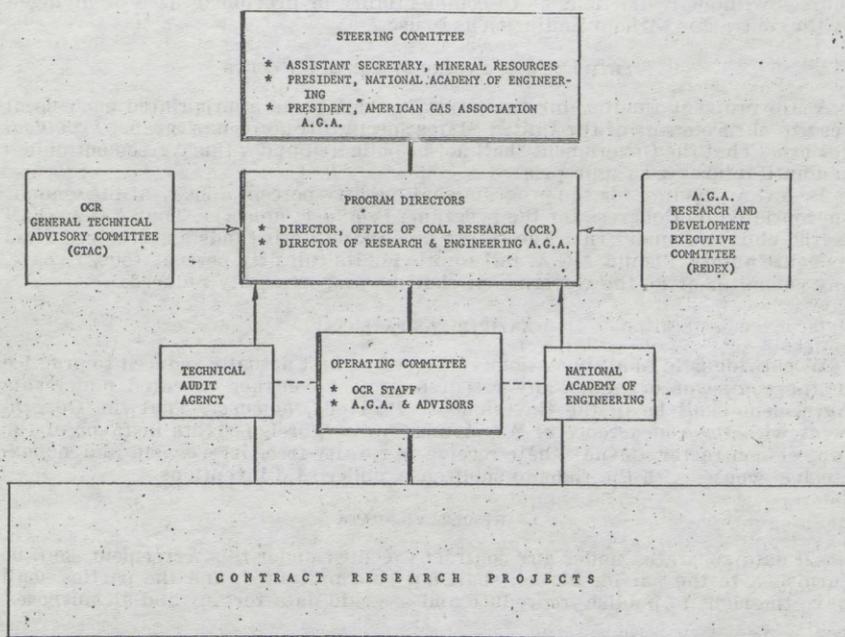
Unless sooner terminated as herein provided, this Agreement shall expire eight years from the date first above written.

In witness whereof, the parties hereto have caused this agreement to be duly executed and their seals affixed the date and year first above written.

DEPARTMENT OF THE INTERIOR,
By ROGERS C. B. MORTON,
Secretary of the Interior.
AMERICAN GAS ASSOCIATION,
By G. J. TANKERSLEY,
Chairman of the Board.

Attest:

F. BOSLEY CROWTHER III, *Secretary.*



CONTINENTAL OIL Co.,
Washington, D.C., November 18, 1971.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR SENATOR JACKSON: In response to your October 14 letter, Continental Oil Company (CONOCO) is pleased to submit these comments on S. 1846 and some recent developments concerning the manufacture of synthetic gas from coal.

Consolidation Coal Company (CONSOL), a wholly-owned subsidiary of CONOCO, is one of the largest producers of coal in the United States and has been engaged in coal gasification research and development for almost 25 years. At present, both CONOCO and CONSOL—in cooperation with the Office of Coal Research—are actively seeking to develop new and more economic processes of converting coal to pipeline quality synthetic gas.

We agree with the underlying motivation of S. 1846, namely that a severe natural gas shortage exists and, with respect to domestic resources, coal-based

synthetic gas will probably provide the primary long-term amelioration of this shortage. Under the circumstances, the need for increased coal gasification research and development and the desirability of undertaking commercial production of synthetic gas from coal as soon as possible is self-evident.

It should be understood that our support of additional research does not mean that private industry is not currently endeavoring to meet the natural gas shortage. Since your July 27-28 hearings on S. 1846, several coal gasification projects have been announced and it is now assured that commercial scale gasification of coal will be an operative fact within the lag time required to open the associated mines and construct the conversion plants and transmission systems. In addition, CONOCO and the entire energy industry are moving forward with plans to build diverse synthetic gas plants utilizing naphtha and liquified petroleum gas as feedstock. At least three such plants have been announced and others are in various stages of planning.

The proximity of the first commercial coal gasification projects, as well as the announcements of plans for other types of synthetic gas projects, is principally the result of not only the growing unavailability of natural gas but also greatly underestimated increases in domestic demands for clean hydrocarbon fuels. These two facts have combined to create a situation where coal gasification and the gasification of liquified petroleum gas and naphtha are economically viable supplementary sources of pipeline quality gas. I should emphasize the supplementary nature of these projects because the plant price of synthetic gas must be many times those of regulated natural gases in order to obtain an acceptable return on the extensive capital investments which will be required.

Your Committee should be aware of two additional points concerning coal gasification. The process which is currently available was developed by the German firm of Lurgi G.m.b.H. of Frankfurt some 30 years ago and has been successfully applied to a wide range of coals in many countries on a large commercial scale. In none of these Lurgi plans has the purpose been to produce a substitute for natural gas, i.e. methane. As a result, the finishing step in the overall process sequence, the so-called methanization, remains untested on a commercial scale. However, a very extensive amount of closely-related commercial experience is available. In our opinion, the methanization step can be safely relied upon to perform satisfactorily and to raise the BTU content of the synthetic gas to an acceptable level.

Finally, your committee should not draw the erroneous conclusion that coal gasification and petroleum liquids gasification are wholly substitutable. There is an enormous difference in the capital investment and the time required to develop the two distinct types of ventures into commercial projects. For example, coal gasification plants—excluding the associated mine development and transmission system expenses—require three or four times more capital investment than naphtha conversion plants. Furthermore, the lead time on any plant utilizing coal is almost five years, as compared to approximately 18 months for naphtha or LPG facilities. However, western coal as a feedstock will be considerably less expensive than naphtha.

In conclusion CONOCO believes it is of utmost importance that the ongoing coal gasification research and development program conducted by the Office of Coal Research and the Bureau of Mines be continued and accelerated as recommended by the President in his June 4 Energy Message. We understand some problems have arisen in Congress which place the funding of this program in jeopardy. We hope they can be overcome so work can proceed without delay on new and improved coal gasification technology.

Sincerely yours,

Theron J. Rice.

QUESTION SUBMITTED BY SENATOR CLIFFORD P. HANSEN TO
EDWARD A. WALSH

NOVEMBER 18, 1971.

Mr. EDWARD A. WALSH,
Vice President, El Paso Natural Gas Co.,
Post Office Box 1492, El Paso, Tex.

DEAR MR. WALSH: I had intended to ask a question or two at the coal gasification hearings concerning El Paso's Algerian project.

Inasmuch as I was testifying before another committee at the time you testified, I asked permission of the Chairman to submit my questions in writing.

I would appreciate your response to the following for inclusion in the record of the hearing.

You mentioned El Paso's Algerian project to liquefy and transport natural gas from that country to the U.S.

Algeria is a country with whom we do not have diplomatic relations and, in fact, I believe a large part of the gas your company would buy from Algeria would be produced from facilities that were formerly owned by U.S. companies before they were expropriated by the Algerian government and for which they were paid, as I understand it, something like 50 cents on the dollar.

I note also in the recent U.S. defeat in the U.N. on the China issue, Algeria co-sponsored the resolution and its representatives embraced one another over their victory.

Further, I understand that the Algerian government owned State Oil Company, Sonatrach, I believe it's called, has applied to the Export-Import bank for a loan to finance its part of this deal with El Paso.

Only this morning I received a letter from William Young, a Casper, Wyoming petroleum geologist from which I would like to quote.

"I have been a resident of the city of Casper and the state of Wyoming for the past 17 years and during that time I have worked as a petroleum geologist for a company and as an independent. I will continue to pursue my profession as long as it is economically feasible to do so, which if the current trend continues, may not be long. I am well aware of your stand on encouragement of domestic exploration and fight against the increased reliance on foreign imports. I read with interest your recent comments in the *Congressional Record* relative to Section 17 of the Alaska Native claims legislation; I could not agree more with your analysis.

"What I would here like to bring forth is one particular aspect of our increased reliance on foreign imports. I recently returned from Algeria where I had accepted a contract for 2 years to work for the state owned oil monopoly, Sonatrach, as an exploration geologist. I took this job simply because of our depressed state of exploration here and my need for money. Well, Sonatrach, at their convenience terminated not only my contract along with many, many other individual contracts, but company contracts as well, without, in many cases, adequate compensation for work performed and equipment purchased. I am still trying to get paid, as per my contract, the 80% in dollars coming to me for the three months in their employ. There are numerous parts and compensations to my contract that they refuse to honor, and that becomes the key word to all negotiations and contracts with the Algerian government, HONOR.

"We here in this country accept without question the validity of a legal contract agreed upon by the parties involved, and, if the occasion arises, have recourse to the courts to resolve any differences of opinion. In Algeria, as I am certain elsewhere in the Arab world, honor is just a word without meaning. To them it is a defense of their own rationalization of the situation at any given time, subject to variation and change as they see fit in their own interests, and not subject to any rebuttal. I understand that several service companies are in the process of initiating suit in the world court to recover moneys owed them. I do know that the economic conflict between France and French companies against the Algerian government is a sample of what our government and U.S. companies might expect in their dealings with these people. I particularly refer to the relationship between the U.S. government, El Paso Natural Gas Company and the Algerian government. I believe that this deal will be one of a number of momentous blunders on our part. I predict that only Algeria, and to some limited extent, El Paso will benefit from the arrangement, El Paso simply because they will not be spending much of their own money for the necessary equipment. I would like to hear of your attitude on this subject and possibly get you to investigate the folly of this and other possible contractual agreements with Algeria and other Arab countries."

I am sorry I was unable to return to the hearing and will appreciate your courtesy in responding.

With kind regards,
Sincerely,

CLIFFORD P. HANSEN.

EL PASO NATURAL GAS CO.,
El Paso, Tex., December 3, 1971.

HON. CLIFFORD P. HANSEN,
*U.S. Senate, New Senate Office Building,
Washington, D.C.*

DEAR SENATOR HANSEN: In response to your letter of November 18, I am pleased to elaborate on the plans to import liquefied natural gas from Algeria for use on the eastern seaboard of the United States. Only a passing reference was made to this project in my testimony before the Senate Interior and Insular Affairs Committee regarding El Paso's plans to build a coal gasification plant.

These unconventional methods of supplying the large and ever-increasing demands for gas must be scrutinized and evaluated in the context of a developing energy shortage in the United States which threatens in a few years to assume critical proportions. Of the several sources of energy, the shortage of natural gas may be the most critical. It is far easier to develop the reasons for this than it is to provide the solutions.

Among the principal forms of energy, only natural gas has been subjected to regulation. The free play of economic factors in our economy determine the price of coal and oil. As contrasted with this, the Federal Power Commission in years past, through the misguided belief that it was serving the interest of the consumers, established wellhead prices for natural gas at an artificially low level, which gave birth to two unfortunate consequences: (1) it greatly reduced the incentive to explore for additional gas, and (2) it encouraged the development of gas markets which the free play of competition might have directed to other forms of energy. Added to these factors was the emerging consciousness of environmental considerations which further encouraged the utilization of gas because of its clean burning, non-polluting characteristics. As an upshot of this, the consumption of gas has recently increased at the rate of seven percent per year. At present, gas supplies more than thirty percent of all of the energy consumed in the United States. Ecological considerations are likely to account in the future for a preference of gas over other fuels if the supply were available.

As evidence of the rapidity with which the available supply of natural gas has deteriorated, I would like to point out that as recently as eight years ago, the Federal Power Commission established, as the desirable inventory of available supply, a deliverability life of not less than twelve years for the nation's pipeline companies. Deliverability life is the period of time in which a company can meet its present market requirements without augmentation of its existing supply of available gas. Today several of the major pipeline companies of the United States suffer from a "zero" deliverability life; that is, their supplies are not sufficient to continue to serve all present demands. Many of the major pipeline companies serving the eastern seaboard have already announced an inability to meet their market requirements and the necessity to curtail customers heretofore reliant upon gas for their business operations. This shortage is by no means limited to the eastern seaboard. It prevails nationwide.

It is in these circumstances that El Paso and others in the natural gas industry are vigorously seeking solutions to the problem. I like to think that the company with which I am associated is pioneering in this effort. You are already acquainted with El Paso's effort in the coal gasification field. El Paso was the first to experiment with nuclear stimulation of low permeability gas-bearing formations. The U.S. Bureau of Mines has estimated that, if successful, this novel method of well completion could double the proven reserves in the United States. The western portion of the country would be the principal beneficiary of any such technique inasmuch as the low permeability formations, for the most part, are located in the Rocky Mountain area.

Obviously, prompt steps should be taken to encourage exploration for natural gas reserves yet to be discovered in the United States. There can be no serious quarrel with the assertion that we should be dependent upon foreign sources of energy only to the extent that they cannot reasonably be expected to emanate from domestic sources. It is thus appropriate in evaluating the importation of LNG to consider the prospects of meeting U.S. gas demands from U.S. sources.

The extent to which this can be realized will be known only after the passage of many years, but strong views by people knowledgeable in this field and certain convincing statistics cannot be ignored.

The Chairman of the Federal Power Commission, in testifying before the Subcommittee on Minerals, Materials and Fuels of the Committee on Interior and Insular Affairs of the United States Senate, on November 13, 1969, indicated that between then and 1990, it would be necessary, in order to provide the minimum reserves necessary to meet projected demands of gas, that discoveries average 36 trillion cubic feet per year. The likelihood of maintaining any such average over such a long period of years must be measured in light of the fact that, in the entire history of the industry covering a time span both before and subsequent to FPC regulation, never was there, in any single year, as much as 25 trillion cubic feet discovered.

The Secretary of Interior, in his report to the same subcommittee on June 15, 1971, stated:

"... We have the making of a widespread shortage in gaseous fuels which will arrive in full force within the next few years, despite anything we might do. While this will in all probability have little effect upon existing residential customers, prospective consumers of all types will have to look to other fuels, and existing industrial customers will be forced to transfer more and more of their demand to alternative sources of energy."

John Carver, a member of the Federal Power Commission, in a speech last May 27, stated: "I think our shortage is endemic, covers all fossil fuels, and is basically incapable of being turned into a surplus short of distressing depression."

Attached is a copy of a letter addressed to Senator Magnuson expressing the view of Mr. John Winger, Vice President of The Chase Bank in charge of the Petroleum Division of that institution, in which he estimates that natural gas supplies from within the United States, including Alaska, will be able to meet only fifty-eight percent of the estimated demand by 1980. You will observe that Mr. Winger further estimates that by that date, even assuming all of the exports that can be expected from Canada, gasification of coal, gasification of naphtha, and the importation of liquefied natural gas, one-third of the nation's gas markets will still go unsatisfied. It is in this context that El Paso's LNG project should be evaluated.

The applications before the Federal Power Commission relating to the El Paso LNG project seek authorization to import one billion cubic feet of natural gas per day. This quantity will represent only 4.7 percent of the natural gas consumed in the area of the eastern seaboard and 1.3 percent of that consumed in the contiguous 48 states.

El Paso, of course, is not insensitive to the political risk inherent in the importation of energy originating in developing countries. The economic interest of El Paso is vitally intertwined with the reliability of the project. The ships furnished by El Paso will cost about six hundred million dollars, of which more than one hundred and fifty million dollars will represent shareholder equity. You will understand, therefore, that the Company has approached this project with caution and, after undertaking properly to evaluate the political risk, has taken steps designed to protect against it. The conditions of the arrangement between El Paso and the Algerians differ materially from that customary in the oil and gas industries.

El Paso does not intend to invest its own funds in Algeria for the facilities there required for the project. All such funds will have to be secured by the Algerians from their own equity and credits established outside of Algeria. The properties identified with this project located in Algeria will be owned by Algeria and therefore not subject to nationalization.

The Algerians will not own the ships required to move the LNG from Algeria to U.S. markets. These ships are economically suitable to no other use than the transportation of LNG. Their special construction makes them among the most expensive commercial ships ever constructed. There are indications that the cost of these ships from U.S. yards will approximate seventy million dollars each. Such ships are built only as part of a specific project and therefore other such ships are not generally available elsewhere in the world for transportation of this LNG to other markets. The time for constructing these ships ranges up to thirty months each after space in a shipbuilding yard becomes available. Moreover, unique land-based facilities in the market area must exist in order to receive, store this product at -259°F. , and regasify it. Such land-based facilities for a project of this magnitude will approach two hundred million dollars in cost.

Thus, arbitrary interference with the supply of LNG would suggest highly undesirable economic consequences to Algeria. It would neutralize the investment that country will have in its own facilities built at a cost to it approximating six hundred million dollars. Sales to other markets could not be accomplished except that such purchaser, after observing a repudiation of the contract with El Paso, was willing to invest nearly six hundred million dollars in ships and another two hundred million dollars in land facilities to receive, store and regasify the LNG. In considering where the product might be marketed, it is worthy of note that Russia is a net exporter of large quantities of natural gas and has projected pipeline sales into Western Europe.

El Paso's contract with the Algerians has a term of twenty-five years, with a pricing formula which admits of limited escalation measured by inflation as indicated by U.S. indices. A further provision of the contract provides that in the event of differences of any nature, they shall be resolved by resort to the International Chamber of Commerce, located at Paris, France.

The U.S. Department of State has indicated its approval of the project in a communication to the Federal Power Commission. El Paso is not privy to all of the considerations influencing the decision of the State Department, but we would expect that the ever-growing energy needs of this country would suggest the wisdom of improving relations with those countries that have great potential natural gas supplies, particularly those located in the Mediterranean area where Russian influence is being expanded daily. The geographical location of Algeria in the Eastern Mediterranean and its huge hydrocarbon deposits accord to it a special status.

The gas for the El Paso project will originate in the Hassi R'Mel field. DeGolyer & MacNaughton, one of the best-known reserve engineering firms in the United States, has estimated that the recoverable quantities of gas from this field, exceed the staggering figure of 60 trillion cubic feet. At no time has any U.S. company ever claimed an interest in this field. As long ago as 1965, the French, which granted independence to the Algerians, surrendered their interest in gas deposits in Algeria in consideration of concessions sought with respect to oil deposits. Although the French at one time challenged the right of Algeria to sell gas to El Paso, such claim has since been abandoned.

It is true that the Algerians have nationalized certain hydrocarbon concessions of American companies which were operating in Algeria. It is our understanding that all of these U.S. companies have accepted the compensation offered to them by the Algerians. It is not surprising that some such companies had hoped for substantially greater compensation. It is our information that settlement negotiations were based upon undepreciated investment, whereas compensation was sought by the U.S. companies on the basis of potential profits which might have been realized from the exploitation of the Algerian natural resources discovered by such companies.

With respect to natural gas, which is the principal subject of this letter, it may be interesting to note press statements that Venezuela, upon which the United States has been so dependent in the past for substantial quantities of oil, has recently asserted that natural gas discovered by U.S. companies was not covered by the concessions and remains the property of the Venezuelan sovereign.

The National Energy Board of Canada announced last week that additional exports of gas to the United States would not be authorized at this time and would be retained to meet Canadian needs. U.S. companies had supplied much of the money and effort involved in the exploration leading to the discovery of this Canadian gas.

As mentioned in your letter, the Algerians have made application to the Eximbank for assistance in financing the facilities to be built in Algeria. The grant of such credits will, of course, be in keeping with the very purpose for which the bank was organized—namely, to encourage the utilization of American-made equipment in foreign countries. The Algerians have already contracted with a U.S. company for the construction of the liquefaction facilities. That company has indicated to us that credits from world money markets outside the United States would also be available to the Algerians in consideration of the use of the equipment from such countries. In fact, such equipment can be purchased at less cost to the Algerians than American-made equipment. In this period of adverse trade balances, it would be unfortunate to see such equipment purchased outside of the United States.

I have trespassed upon your indulgence in the length of this response, but I feel that the significance of the energy shortage facing this country and the importance of developing supplementary sources of natural gas justified the detail to which I have resorted. If I can be of any further help in describing El Paso's LNG project, I do hope that you will call upon me to do so.

Sincerely yours,

EDWARD A. WALSH, *Vice President.*

THE FOLLOWING CORRESPONDENCE AND MATERIAL WAS SUBMITTED BY SENATOR JENNINGS RANDOLPH

U.S. SENATE,
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C. November 30, 1971.

MR. WILLIAM D. RUCKELSHAUS,
Administrator, Environmental Protection Agency,
Washington, D.C.

DEAR MR. RUCKELSHAUS: On November 18, 1971, the Committee on Interior and Insular Affairs received testimony from the Department of the Interior and others on coal gasification. During these hearings, which were conducted as part of the National Fuels and Energy Policy Study (S. Res. 45), there was discussion of the research program of the Environmental Protection Agency on advanced power cycles employing on-site coal gasification.

Would you supply for the record a summary of your Agency's research, development, and demonstration program on advance power cycles. Your response by December 20, 1971, would be appreciated.

Sincerely,

HENRY M. JACKSON, *Chairman.*

ENVIRONMENTAL PROTECTION AGENCY,
Washington, D.C., December 28, 1971.

HON. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: This is in response to the November 30, 1971, letter from you and Senator Randolph requesting information on the EPA Advanced Power Cycles Program for the Committee on Interior and Insular Affairs. We believe that the full implementation of such a program would make a large contribution in our efforts to clean up the environment, while maintaining the nation's economic growth.

As part of the EPA research and development program, our Control Systems Division (CSD) is investigating a number of different techniques which will be useful to the utility industry in controlling the emissions of sulfur oxides and particulates from their generating plants. To date, the major commitment of resources has been directed toward the development of stack gas cleaning devices. However, once developed, application of these stack gas cleaning systems, along with conventional electrostatic precipitators, will result in added capital and operating costs to the utilities and ultimately to the consuming public.

Concern over these increased costs led EPA to commission a study to determine whether there were more efficient ways of producing electricity than the conventional steam power plant. This study, for the "Technological and Economic Feasibility of Advanced Power Cycles and Methods of Producing Nonpolluting Fuels for Utility Power Stations", Contract CPA 22-69-114, was let in July 1969. The work was carried out by United Aircraft Corporation with the subcontract assistance of Burns and Roe, Inc., and the FMC Corporation. If ways could be found to more efficiently produce power, perhaps the savings in cost would offset the cost of pollution control equipment. The study was completed and did, indeed, identify a power cycle which had a potential for increased efficiency over the conventional steam plant. This advanced power system promises efficiencies on the order of 50 percent, in contrast to conventional steam power systems which have been optimized at 39 percent.

The advanced power cycle identified by our study consists of a coal gasifier to produce a low-BTU fuel gas, a gas clean-up system, a gas turbine and a steam turbine. The air pollution control potential of this system derives from the opportunity for removing both sulfur oxides and particulates in concentrated form. Sulfur compounds such as H_2S (a product of gasification) are easier to reduce to much lower levels than are sulfur oxides. We also have reason to believe that the formation of nitrogen oxides would be reduced. Thus, when developed, the advanced power cycle with coal gasification and fuel clean-up combine to provide an economic sulfur and particulate-free electrical generating system which could provide a less expensive power source than conventional steam plants equipped with stack gas cleaning devices.

A rough outline of our proposed plan at this time is as follows: Build a complete gasification, clean-up, gas turbine and steam turbine plant, using state-of-the-art components at the 50-100 MW demonstration level. The selected size would be tailored to the largest available full-scale gas turbine or gasifier, whichever is smaller. Such a plant would be of modular design, so that as improved components are developed, they can be substituted in the system. A critical part of this plan is a concurrent development program aimed at improving the various components until the optimum efficiency of the system is achieved. The advantages of this system are its flexibility as a test laboratory for newly developed components and the clear demonstration of the pollution-free potential of the advanced power cycle. The total cost of this project, over a period of eight to ten years, is estimated to be approximately \$75,000,000. We have already obtained indications that as much as two-thirds of this cost could be obtained from the industry contractor team.

Further details and discussion of this program are given in the document which is enclosed.

In addition to the above, EPA has extensive current programs which are related either directly or indirectly to low BTU coal gasification and high temperature gas clean-up. These include: (1) modification of the Consolidation Coal Company CO_2 acceptor process to produce low BTU gas from coal, (2) The Applied Technology Corporation's molten iron submerged gasification process to produce clean low BTU fuel from coal, (3) various fluid bed combustion processes incorporating sulfur scavengers to produce sulfur free combustion products, (4) evaluation of sulfur scavengers for hot and cold gases, (5) theoretical studies on the mechanism of coal desulfurization, and (6) high temperature particulate removal studies.

A similar response has been sent to Senator Randolph. I want to thank you for the opportunity to submit this information, and if further details would be helpful, please do not hesitate to contact me.

Sincerely yours,

WILLIAM D. RUCKELSHAUS, *Administrator.*

Enclosure.

COAL GASIFICATION/ADVANCED POWER CYCLE

CONTROL SYSTEMS DIVISION

ENVIRONMENTAL PROTECTION AGENCY

December 10, 1971

1. INTRODUCTION

The advanced power cycle encompasses four branches of technology which combine to form the basis of a power cycle that promises a high level of pollution control and excellent thermodynamic efficiency. This technology consists of fuel gasification to produce low to medium BTU gas from fossil fuels; fuel gas decontamination to remove sulfur and nitrogen fuel compounds and particulates; gas turbine technology; and steam turbine technology. Currently a sufficient technological base exists to package an advanced power cycle plant that could achieve pollution control, efficiency, and economics comparable to contemporary fossil fired plants employing flue gas clean-up systems, clean fuels, or a combination of these. The ultimate potential of the cycle, if developed as proposed, is considerably better with efficiencies projected to 50% and emissions reductions magnitudes lower (e.g., SO₂ emissions less than 50 ppm). This potential can be achieved through development efforts to improve gasifier technology currently restricted to fixed-bed types marketed by a German firm, Lurgi to improve pollution control processes currently restricted to processes for "sweetening" natural gas; and increases in high temperature capabilities of gas turbine materials from 1900° to 2800°F.

The Advanced Power Cycle Program involves the demonstration of a 50-150 MWe current state-of-technology plant consisting of modular components including gasifier, gas clean-up system, and combined gas turbine/steam

turbine plant. Simultaneous development of advanced components will be undertaken and tests of these advanced components will be conducted in the demonstration plant as the final phase of the program. The program is anticipated to cost \$75-100 million dollars over a 8-10 year period with industry cost-sharing at least 50% and possible two-thirds of this cost. The complexity and cost of the program will require team participation by industry. Selection of the most qualified industry team will be made on basis of competitive six month studies, termed "Program Definition Phase Contracts" (PDP), awarded to a maximum of four industry teams. Selection shall be made by a Source Evaluation Board appointed by EPA and consisting of representatives from EPA and other government agencies as appropriate.

Successful development of the proposed advanced power generating system offers a combination of environmental and economic advantages:

A. Environmental

1. Up to 99% reduction of sulfur oxides
2. Anticipated reduction of nitrogen oxides of 90% compared to present coal fired power plants
3. Virtual elimination of particulates
4. Anticipated reduction of thermal pollution of approximately 40-50%

B. Economic

1. Savings of advanced power system over conventional steam plant with clean-up of approximately 20-30% for both capital and operating costs. Thus the advanced power system will produce pollution free electricity with no additional costs to the consumer.
2. Definite and measurable impact on balance of payments if the system is successfully developed in the United States, due in part to saleability of complete systems and part to royalties from foreign licensees of United States turbine

manufacturers. Additionally, successful United States development will forestall possible foreign domination of a market estimated to be worth approximately \$60 billion in the decade 1990 to 2000.

3. Forestall a postulated adverse affect on the coal industry affecting both revenues and employment, i.e. possible loss of revenues of \$1 billion annually and employment reductions of some 30% in the six (Pennsylvania, West Virginia, Ohio, Indiana, Illinois and Kentucky) leading coal producing states affecting some 44,500 people.
4. Permit the limited supplies of natural gas to be directed towards area sources in major urban areas.
5. There will be a beneficial near-term effect on the gas turbine industry affecting the employment of highly trained turbine designers. The effect will be to maintain an existing capability which might otherwise be dispersed due to curtailment of DOD support and loss of the SST.

II. IMPORTANCE

Sulfur and particulate matter are the prime environmental offenders when coal is burned directly as a fuel for electric power generation and in industrial processes. In 1969, the combustion of coal, primarily electric utility and industrial power or steam plants, contributed 60% of the sulfur oxides emissions in the United States. A significant share of the particulate and nitrogen oxides emissions were also attributed to this source of combustion.

The Environmental Protection Agency, has long recognized the need to control this important source of air pollution and has mounted both short and long-term programs to develop solutions. In the short-term, specifically

clean-up systems which for the most part are add-on aqueous scrubbing systems. Since these systems must purify large volumes of gas after the coal is burned the systems are large and, thus, costly and are limited in efficiency of removal to a maximum of approximately 90%.

The best solution ultimately is to burn clean fuels, i.e., fuels which do not contain sulfur, nitrogen, or ash. While there are naturally-occurring clean fuels, these are either scarce, located at great distances from where they are needed, or must be saved for more critical applications, such as iron and steel making. Consequently, the long-range programs of EPA, and those of the Department of Interior, are concentrating on processes which produce clean synthetic fuels, and include such programs as physical and chemical cleanup of coal, desulfurization of coal and oil, coal gasification, and coal conversion.

Of particular significance to the power industry is the advanced power cycle which involves gasification of coal and combustion in a combined cycle power plant, i.e., a power plant incorporating gas turbine and steam turbine technology in a highly efficient configuration. In fact, the importance of the advanced cycle was stressed in a report of national significance by the Electric Research Council.

The report of the R&D Goals Task Force to the Electric Research Council entitled "Electric Utilities Industry Research and Development Goals through the Year 2000" was published in June 1971. This report calls for a greatly expanded R&D program for the utility industry and defines goals and priorities for this program. Among the Priority 1 goals of the R&D program (Priority 1 goals are defined as having indispensable effect on the ability of the electric

processing, especially coal gasification/combined cycle power generation.

The objective of coal gasification and the advanced power cycle is to permit expanded utilization of coal, which constitutes 80% of the known recoverable fossil fuel reserves of the United States, in a manner not contributing to air pollution. Table I indicates the fossil fuel resources of the United States and shows that coal is by far the most abundant energy resource. Figure 1 indicates that even with the anticipated growth of nuclear energy, coal consumption is expected to more than triple by the turn of the century and thus will continue as an important energy source well into the next century. Table II compares 1960 energy consumption with projected energy consumption in the year 2000. Of particular interest is the fact that the fraction of total energy consumed in the United States as electricity is expected to increase from 20% in 1960 to 45% in 2000.

The most compelling factor supporting the expanded utilization of coal in the United States is indicated in Table III. Only in the case of coal could known recoverable reserves meet the cumulative consumption during the period 1960-2000 at costs comparable to current conditions. In the case of natural gas, consumption will deplete even the total estimated reserves, assuming no limitation in recovery costs.

The previous tables have indicated the energy potential of coal and its importance as a fuel for electrical generation. Unfortunately, the achievement of this potential is constrained by the current pollution problems associated with coal utilization. For example, the average sulfur content of coal used for steam generating purposes in the United States is about 2.7% (2.1 lbs. S/MBTU). This results currently in about 22 million

TABLE I
FOSSIL-FUEL RESOURCES
(10^{18} BTU)

FUEL	KNOWN RECOVERABLE RESERVES	KNOWN RESOURCES	UNDISCOVERED RESOURCES
COAL	4.6	29	55
PETROLEUM	0.23	0.23	1.7
NATURAL GAS	0.28	--	0.9
NATURAL GAS LIQUIDS	0.03	--	0.3
SHALE OIL	0.29	11.6	23
TOTAL FOSSIL FUEL ENERGY	5.5	41	81

TRENDS IN FUEL DEMAND FOR ELECTRIC POWER GENERATION

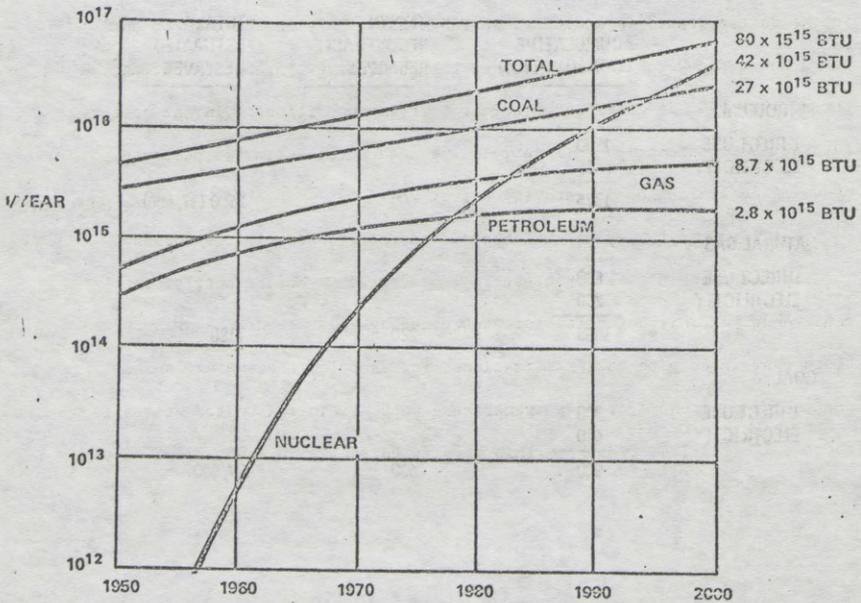


TABLE II
PROJECTED ENERGY CONSUMPTION
 10^{15} BTU/YEAR

	RESIDENTIAL	COMMERCIAL	TRANSPORTATION	INDUSTRIAL	OTHER	TOTAL
1980						
DIRECT USE	6.6	2.4	9.2	11.6	6.2	36
ELECTRICITY	2.2	1.3	0	4.0	1.0	8.5
2000						
DIRECT USE	8	5	37	35	13	98
ELECTRICITY	22	10	0	45	3	80

TABLE III
COMPARISON OF CONSUMPTION WITH RESOURCES (1960-2000)
 $(10^{15}$ BTU)

	<u>CUMULATIVE CONSUMPTION</u>	<u>KNOWN RECOVERABLE RESERVES</u>	<u>TOTAL ESTIMATED RESERVES</u>
PETROLEUM			
DIRECT USE	1300		
ELECTRICITY	75		
	<u>1375</u>	600	2500 (37,500) + (SHALE OIL)
NATURAL GAS			
DIRECT USE	600		
ELECTRICITY	200		
	<u>1000</u>	200	1180
COAL			
DIRECT USE	300		
ELECTRICITY	600		
	<u>900</u>	4600	89,000

emission in the U.S.).

The Standards of Performance for New Stationary Sources recently established by EPA require emissions from stationary coal fired steam generating sources to be reduced to the equivalent of 0.6 lb. S/MBTU coal. Coal at this sulfur level currently constitutes approximately 18% of the total steam coal supply available to the steam generating industry. Based on continuation of the current steam coal production growth rate of approximately 7% per year, as projected by the coal industry, it is expected that the low sulfur coal will continue to represent only between 16% and 18% of the total supply for the 1970-1990 period.

The estimated effect of various strategies to increase the availability of low sulfur coal and oil using existing commercial technology is presented in Figure 2. Any effort to project the strategies beyond 1990 should be viewed with caution because of limitations on known recoverable fossil fuel reserves. The strategies in this effort are defined as follows:

- Strategy 1. A growth rate in 0.6 lbs. S/MBTU fuel production (oil + coal) continues to follow historical growth patterns of approximately 7% annually. This represents the baseline.
- Strategy 2. The availability of 0.6 lbs. S/MBTU fuel is increased through the maximum use of existing commercial desulfurization technology applied to current Eastern steam coal production and South American residual oil production consumed in the United States.
- Strategy 3. Production of Eastern (Appalachian and Eastern Interior region) 0.6 lbs. S/MBTU sulfur coal is increased to the maximum, based on a 20-year lifetime of reserves. Western coal production is expanded only to meet the total demand growth of coal fired Western steam generating capacity. The supply growth rate in domestic and Free World residual oil consumed in the United States is increased from 7% to 8%.

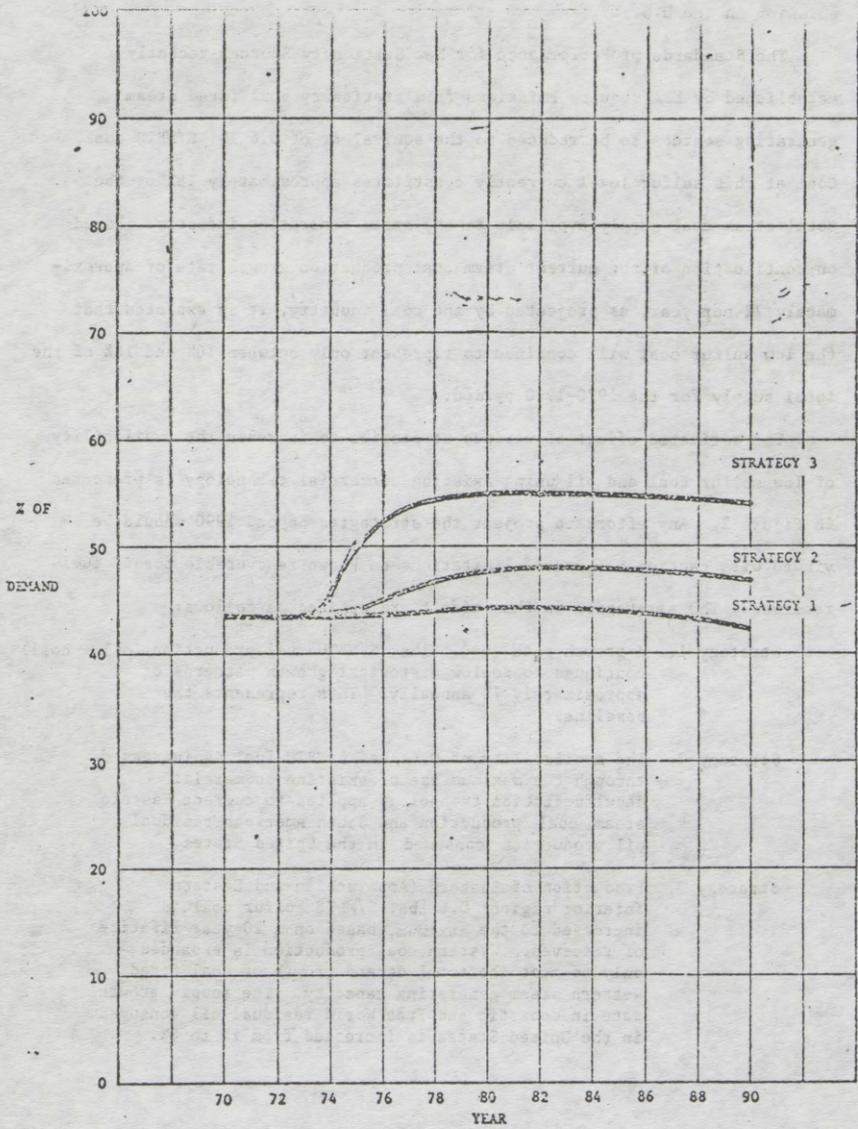


FIGURE 2
TOTAL FOSSIL FUEL AVAILABILITY

TABLE IV
COSTS FOR SO_x CONTROL

	<u>% APPLICATION</u>	<u>ADDITIONAL COSTS/10⁶ BTU</u>
WESTERN EASTERN LOW SULFUR PHYSICALLY DESULFURIZED	20%	\$0.40/10 ⁶ BTU
	13%	\$0.25/10 ⁶ BTU
	7%	\$0.10/10 ⁶ BTU
SIDUAL OIL	25%	\$0.30/10 ⁶ BTU
FLUE GAS CLEANING	35%	\$0.15/10 ⁶ BTU
WEIGHTED AVERAGE	100%	\$0.25/10 ⁶ BTU

ANNUAL COST

1975	—	\$4.5 X 10 ⁹
1980	—	\$6.5 X 10 ⁹

be met with 0.6 lbs. S/MBTU fossil fuel applying these strategies. It can be seen that at best, the naturally-occurring clean fuels supply would meet only 55% of demand, provided projected demands are sufficiently accurate and that these strategies could be implemented. With this limitation in clean fuel availability a practical strategy for achieving low sulfur levels from coal and residual oils in large electric utility and industrial steam plants must examine other options.

Table IV presents the applicability and cost of the near-term strategy control of coal and residual oil to the 0.6 lb. S/MBTU level using natural low sulfur coal, existing fuel desulfurization technology, and existing stack gas control technology. The weighted average incremental cost of achieving this strategy is estimated as \$0.25/MBTU or \$4.5 billion in 1975 based on the total consumption of residual oil and coal. This cost will increase proportionally to the increasing fuel demands of the stationary steam generating industry. Clearly, such a cost for pollution control is undesirable and a longer-range, low-cost, non-polluting means of generating power should be developed. The advanced power cycle is such a solution.

The relationship between percentage of population living within the primary SO_x Air Quality Standard ($80 \mu\text{g}/\text{m}^3$) and the average sulfur content of fuel consumed in stationary sources is graphically indicated in Figure 3. A survey of fossil fuel consumption in all stationary sources indicates the following percentages and average sulfur contents on a national basis:

TABLE V
FOSSIL FUEL CONSUMPTION

	<u>% of Total Consumption</u>	<u>Average lb. S/MBTU</u>
Coal	22	2.1
Residual Oil	11	1.5
Distillate Oil	15	0.2
Natural Gas	52	0

U. S. POPULATION WITHIN SO_x AIR QUALITY STANDARD ($30 \mu\text{g}/\text{m}^3$)

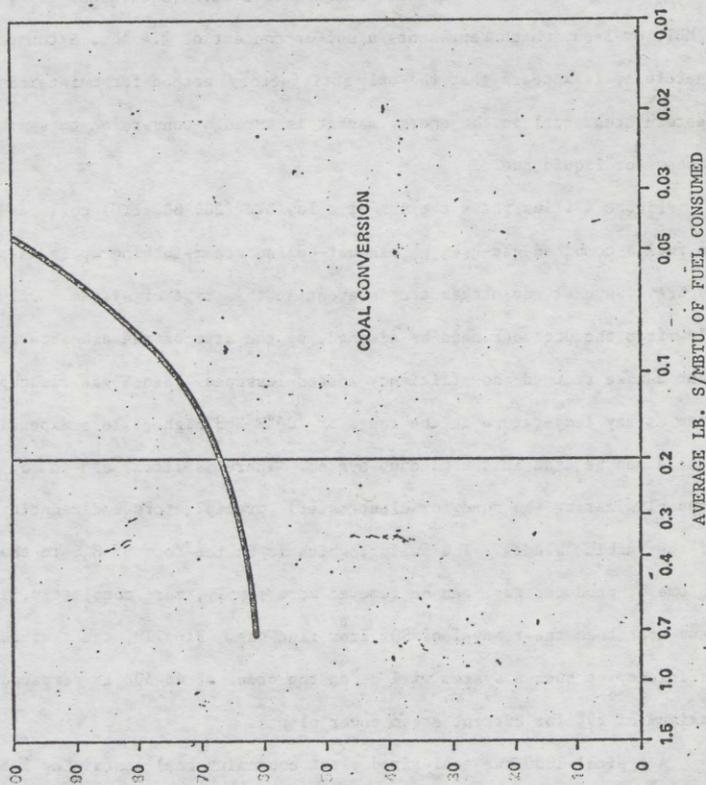


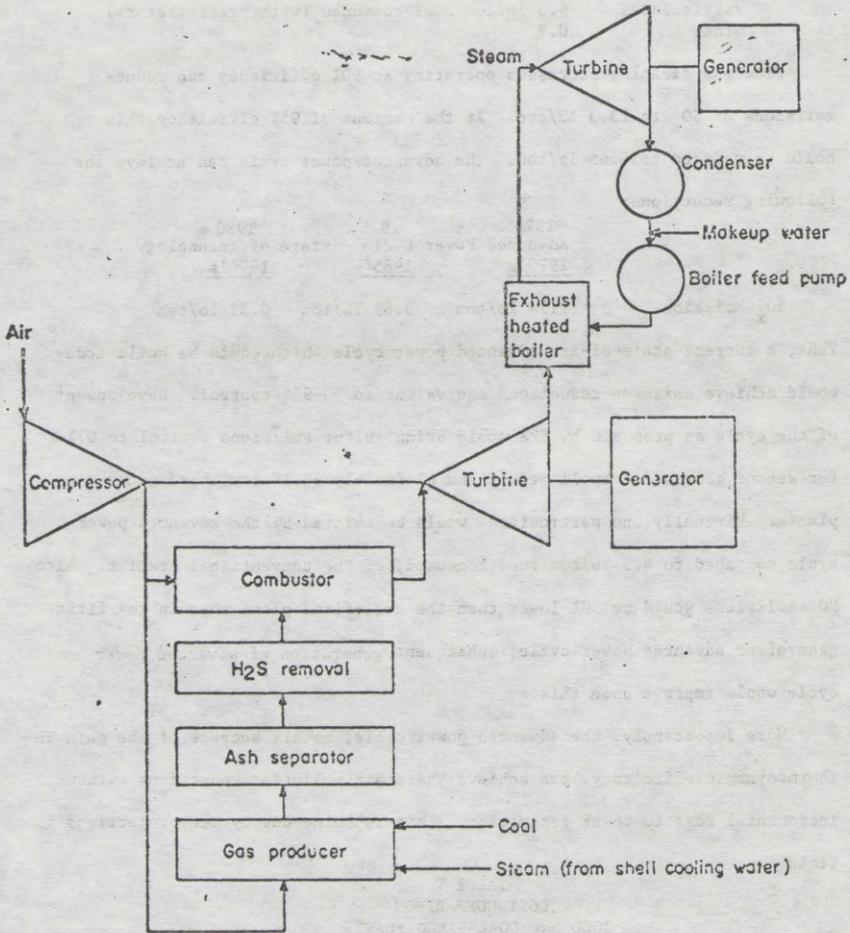
FIGURE 3

sources is about 0.7 lb. S/MBTU. At this level, about 40% of the U. S. population is living under ambient SO_x conditions which are considered unacceptable from the standpoint of public health.

Achievement of the primary SO_x air quality standard for this 40% of the population (mainly the major Eastern urban problem areas) will require the control of emissions from all sources to a level equivalent to 0.1 lb. S/MBTU or less, which represents a sulfur content of 2.4 lbs. S/ton coal. Therefore, it appears that the only satisfactory method for maintaining Eastern steam coal in the energy market is through conversion to synthetic gaseous or liquid fuels.

Figure 4 illustrates the use of a low BTU (200-300 BTU) coal gas producer to fuel a combined gas-turbine, exhaust-heated steam-turbine cycle as proposed by EPA. Several advantages are inherent in this type of system. Only the gas flow from the producer need be cleaned, so the size of the ash-separator equipment can be reduced and efficiency losses lessened. Since gas cleanup can be done at any temperature in the range of 700°F and higher, less expensive metals can be used in the cleanup system. There is little ash in the flue gas, thus eliminating the need for electrostatic precipitators and reducing erosion of the turbine blades. The sulfur, which is in the form of H_2S in the smaller volume of producer gas, can be removed more simply, more completely, and at less cost than the removal of SO_2 from flue gas. Finally, the thermodynamic efficiency of such a system will be on the order of 45-50% as compared to a maximum of 39% for current steam power plants.

A typical 1000 MWe coal-fired plant consuming coal containing 3.5% Sulfur and 9% ash emits the following:



Pressurized gas producer—gas turbine cycle combined with exhaust-heated steam cycle.

Particulates	4.3 lb/ton fuel consumed (with precipitators)
Other	0.7

Flue gas cleaning processes operating at 90% efficiency can reduce emissions of SO_x to 13.3 lb/ton. At the maximum of 95% efficiency this could be reduced to 6.65 lb/ton. The advanced power cycle can achieve the following reductions:

	1970 Advanced Power Cycle - state of technology <u>1970's</u>	1975 <u>1985's</u>	1980 state of technology <u>1990's</u>
SO _x Emission	9.74 lb/ton	3.69 lb/ton	0.31 lb/ton

Thus, a current state-of-art advanced power cycle which could be built today would achieve emission reductions equivalent to 90-95% control. Development of the cycle as proposed by EPA would bring sulfur emissions control to 97% for second generation applications and ultimately 99.7% for third generation plants. Virtually, no particulates would be emitted by the advanced power cycle compared to 4.3 lb/ton fuel consumed, of the conventional station. Also NO_x emissions would be 90% lower than the coal-fired plant even in the first generation advanced power cycle; subsequent generation of advanced power cycle would improve upon this.

More importantly, the advanced power cycle, mainly because of the gain in thermodynamic efficiency, can achieve these air pollutant reductions without incremental cost to power generation. This is borne out by the projections in Table V.

TABLE V
COST COMPARISON
1000 MWe COAL-FIRED PLANT

Type	1970's		1980's		1990's	
	Conventional	APC*	Conventional	APC*	Conventional	APC
Gasifier	-	Lurgi	-	Slagging	-	Slaggi
Gasifier Pressure (atm)	-	21	-	14	-	22
Gas Turbine Temp. °F	-	2200	-	2800	-	3100

TABLE V (cont.)

Type	1970's		1980's		1990's	
	Conventional	APC*	Conventional	APC*	Conventional	APC*
Gas Turbine Compression Ratio	-	8	-	12	-	20
Steam Cycle psi	2400	2400	3500	2400	3500	2400
Efficiency	36.6	36.1	38.6	47.6	39.6	49.9
Capital Cost \$/Kw	174.8	167.5	160.7	127.3	160.7	124.0
Bus bar cost (mills/Kwhr)	6.23	7.23	5.76	5.24	5.72	5.14
Cost of SO ₂ Control (mills/Kwhr)	1.50	-	1.25	-	1.00	-
Total Bus Bar Cost with Controls (mills/Kwhr)	7.73	7.23	7.01	5.24	6.72	5.14

*APC - Advanced Power Cycle

PAY-OFF

The long-term pay-off of the proposed advanced power cycle is complete control of air pollution and reduced thermal pollution in power plants without additional electrical generating costs attributable to pollution control.

The cost benefit ratio can be best seen by examining the growth in installed electrical capacity if the current doubling rate of the industry of ten years is sustained:

	<u>1970</u>	<u>1980</u>	<u>1990</u>
Electrical Generating Capacity(MWC)	330,000	660,000	1,320,000

This new capacity can be characterized into three categories: (1) Base load (75% load factor, >500 MW per unit). It is expected that the development of nuclear plants will supplant existing large capacity fossil plants to satisfy this category which represents approximately 60% of the total capacity; (2) swing load or intermediate (40-50% load factor, 200-500 MW per unit). This category is viewed as the major application of the advanced power cycle and represents approximately 30% of the total capacity; (3) Peaking (<40% load factor, fast reaction time, <200 MW per unit). This category is expected to be satisfied by gas turbines; although the advanced power cycle could also serve this require-

could be completed by 1975 the market potential for the advanced power cycle is tabulated in table VI and is based upon advanced power cycles competing for the intermediate capacity plants.

TABLE VI
MARKET POTENTIAL FOR ADVANCED POWER CYCLE

Assumption: Current State-of-Art Demonstration Complete by 1975

	<u>Fossil Fired Intermediate Capacity Additions (MWe)</u>	<u>Market Capture (%) Assumed</u>	<u>Advanced Power Cycle Orders (MWe)</u>
1975	13,900	10	1400
1976	14,800	10	1500
1977	15,900	15	2400
1978	17,000	15	2600
1979	18,200	20	3600
1980	19,400	20	3900
1981	20,800	25	5200
1982	22,300	25	5600
1983	23,800	30	7100
1984	25,500	30	7700
1985	27,300	40	10920
1986	29,200	45	13140
1987	31,200	50	15600
1988	33,417	55	18400
1989	35,800	60	21500
1990	38,300	65	24895

With a two-three year lead time between order and operation of an advanced power cycle, 5300 MWe of advanced power cycle plants could be on line by 1980, and 80,660 MWe on line by 1990.

Previous table V showed that the advanced power cycle could gain at least 1.5 mills/kwhr cost advantage over conventional plants with sulfur controls. Application of this unit savings to the forecasted generation load provided by advanced power cycles computes annual savings of \$55.7 million in 1980 and \$850 million in 1990. Table VII tabulates the annual savings for all years between 1977 (first commercial units on line) and 1990. The accumulated savings to the consumers would be approximately \$3.8 billion between these years.

78	1400	15
79	2900	30
80	- 5300	56
81	7900	83
82	11500	121
83	15400	162
84	20600	216
85	26200	275
86	33300	350
87	41000	430
88	- 51900	545
89	65000	683
90	80660	850
Total Savings		\$3,800

With costs of development for the advanced power cycle estimated at \$100 million the cost benefit ratio for power savings alone would be:

$$\text{Cost Benefit Ratio} = \frac{\text{Cumulative savings}}{\text{Investment cost in development}}$$

$$= \frac{\$3.8 \text{ Billion}}{\$0.1 \text{ Billion}} = 38$$

Not included in the cost benefit ratio are the costs of pollution in terms of human health and welfare since these are areas which are difficult to reduce to precise definition of cause and effect and dollars and cents.

However, in the August 21, 1970 edition of "Science" an article by Lave and Seskin entitled "Air Pollution and Human Health", an estimate of \$4.887 billion is presented as the annual cost of all respiratory disease. Of this amount, they postulate that a 50% reduction in air pollution in major urban areas would effect a savings of 25% or \$1.222 billion. Damage to materials and vegetation resulting from sulfur oxides have been estimated as follows:

Material damage	.5 to 4.5 billion
Vegetation	35 to 75 million
Property value degradation	2.6 to 4.1 billion

Thus there is an approximate annual cost of some \$8 billion due to air pollution as it pertains to health, vegetation and property values.

readily apparent. Foreign domination of the advanced power cycle program is a real possibility if the U.S. does not gain a leadership position.

A German utility (STEAG) currently has under construction a coal gasifier, combined cycle system at their Kellerman Station in Lunnen, Germany. This plant will have a power output of 170 MW (74 MWGT & 96 MWST) and cost approximately \$20 million, however, it will not provide for sulfur removal. Additionally, feasibility studies are currently being performed by American Lurgi Company, the U.S. subsidiary of the German firm Lurgi Gesellschaften, for the application of the Lurgi process to U.S. coals and utility plants. Support for the study is provided by Commonwealth Edison Company.

Development of the advanced power cycle would effectively place U. S. industry in a position to ward off foreign intrusion into the domestic market. Further, through direct sales and licensee arrangements U.S. industry could gain a share in the foreign market and contribute a favorable input to the balance-of-trade situation.

Another substantial impact could be made upon the coal industry which currently produces \$3.8 billion worth of coal with 127,794 workers and a pay-roll of \$1.2 billion. If high sulfur coal cannot be marketed, a substantial reduction of the bituminous coal industry could occur.

Currently, about 400 million tons of coal are produced annually in the Appalachian and Interior coal regions for steam generating purposes. This constitutes about 90% of total U.S. steam coal production. Of this total, about 150 million tons exceeds 2.5 lbs. S/MBTU sulfur content. As a result, this coal cannot be used economically even with flue gas control processes currently in development to achieve the EPA emission standard for steam

severe in Illinois, Ohio, and western Kentucky, where essentially all steam coal production is greater than 2.5 lbs. S/MBTU. Only through coal conversion can this coal production remain in the energy market. Aside from the catastrophic energy loss, elimination of this production would result in the following:

- a. A loss in revenue to the coal industry of \$1 billion annually.
- b. Severe reduction in force by the coal industry. Estimates by state are as follows:

	<u>Reduction in Number of Mine Workers</u>
Pennsylvania	8,000
West Virginia	15,000
Ohio	5,000
Indiana	1,500
Illinois	7,000
Kentucky	6,000
Total	<u>44,500</u>

This reduction represents about 30% of the current work force employed in the U.S. bituminous coal industry.

The development work conducted under the advanced power cycle program would spin-off technology to other areas with the gasifier development being directly beneficial to other coal gasification programs and the gas-cleanup efforts relating directly to the desulfurization of natural gas at the well-head, refinery gases, and smelter gas.

Less obvious is the spin-off to the currently depressed aerospace industry. Gas turbine development for stationary electric generation has historically been a "spin-off" from aircraft turbine technology. In fact, the peaking turbines currently used are basically aircraft engines geared to generators. The funding for turbine development has been provided primarily by the

for the past five years at above \$50,000,000, 60% of which has been provided by DOD and the remainder by industry. As a result of the inflationary trend of about 5% per year, the buying power of this \$500,000,000 has, however, reduced about 27% between FY 1965 and FY 1970. About 20%, or \$100,000,000, is engineering manpower burden. The impact of DOD retrenchment on engineering manpower has been even more severe than implied by the inflationary rate. The retrenchment has greatly reduced the production of turbine hardware, thus increasing the overhead burden on the industry. Whereas in earlier periods, heavy production commitments permitted the "carrying" of engineering talent on overhead between development contracts, this no longer is the case. R&D contracts follow a cyclic nature between the major turbine manufacturers. During peaks, a major manufacturer may have an R&D expenditure for turbines of \$200,000,000; in the valleys, this expenditure is reduced to on the order of \$100,000,000. The period between peaks and valleys has been roughly five years. This rapid change, no longer absorbable by overhead, has created a situation in which not 25% but as much as 80% of the R&D engineering force is cyclically broken up and released from employment. First, this severely affects the quality of engineering teams assembled and, secondly, the constant effect of inflation tends to further magnify the problem.

The initiation of the coal gasification/combined cycle program would offset this situation in the following manner:

1. Provide between \$1.5 and \$2.0 million annually for turbine R&D during the period of FY 1973 - FY 1977. Additional industry funding through independent corporate research and development (IR&D) can be expected, particularly if a proprietary position seems possible. This total amount could reach approximately \$15 million annually for the five-year period. This funding will have a particularly significant effect on immediately stabilizing the engineering manpower of the turbine industry, since the early efforts will emphasize design, analysis, and pilot plant demonstration.

per man year, this would directly employ 250 professional engineers. More importantly, it would stabilize nearly 15% of the total R&D engineering force of the turbine industry; a particularly significant factor, since the quality of the R&D team and its results are generally based on maintaining the top 15% of the team.

2. A second immediate result of the coal gasifier/ combined cycle program will be to advance the state-of-the-art of turbine performance. Of particular interest is increased (1) turbine inlet temperature from the current limit of 2200°F to 2800°F and (2) pressure ratios, thus achieving improved thermal efficiency. This effect is indicated below in Table VIII.

TABLE VIII

TURBINE THERMAL EFFICIENCY RELATIONSHIPS

PRESSURE RATIO	TURBINE INLET TEMP. °F	THERMAL EFFICIENCY %
7	2000	33
12	2000	36
12	2800	42
40	2800	49

Turbine inlet temperatures on commercial turbines are currently limited by convective heat transfer considerations. Increasing this temperature limit depends on (1) the development of temperature-resistant, high-strength composite or refractory materials and (2) development of internal impingement or external film cooling in a manner which does not extract excessive energy from the compressor sections.

This effort at improving turbine engine output and efficiency is directly relatable to the requirements of military and advanced commercial aviation. Until turbine inlet temperatures can practically be raised above 2200°F, turbine-driven aircraft are limited to speeds below Mach 3.5.

IV. BUDGET IMPACT

The total Advance Power Cycle program cost is estimated at \$75 to \$100 million with industry expected to cost share at least 50% and possibly two-thirds of this cost and the government contributing the remainder. The annual cost to EPA over the 8-10 year period will fluctuate between \$2-5 million.

during the construction of the demonstration plant.

EPA would also provide direct and indirect support to the program through on-going and planned programs in the areas of gas clean-up processes, new and novel gasification techniques, and fluidized-bed technology.

The schedule for the advanced power cycle is shown in Figure 5. A six month program definition phase would be initiated early in 1972 with participation by three to four industry teams. By the middle of the year these contractors will submit comprehensive program plans defining conceptual designs, developmental tasks, construction plans, and testing programs. Selection of the most qualified industry team would follow shortly thereafter. The program would be conducted in three phases: Phase I - design, construction and operation of a current state-of-the-art demonstration plant; Phase II - simultaneous performance of development programs to improve gasifiers, gas clean-up systems, and gas turbines; Phase III - incorporation of advanced components in the demonstration plant and final test of the advanced power cycle.

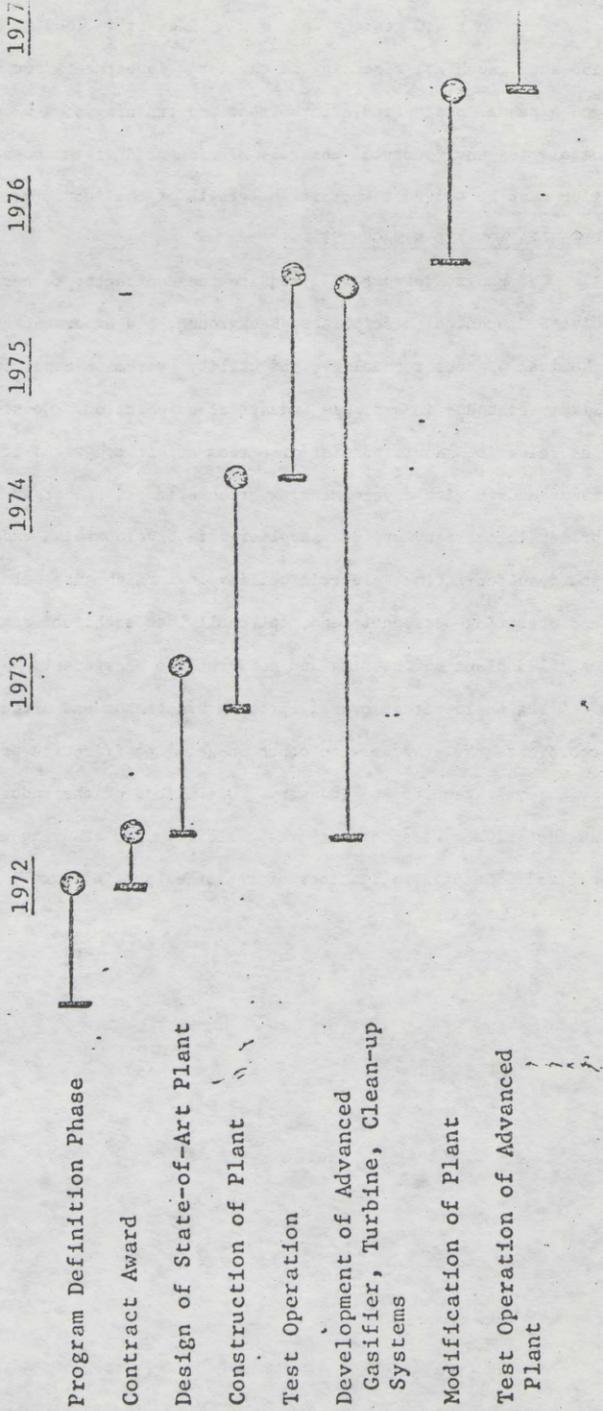
V. NON-FEDERAL SUPPORT

Industry has already submitted unsolicited proposals to EPA along the financial terms discussed above for the complete 8-10 year program. In fact, the cost-sharing provisions of one of these proposals offered better than 50% sharing. Also all the necessary participants, i.e., power equipment manufacturer coal company, electric utility, and architect-engineer, were represented amongst the proposed team effort. We, therefore, expect total costs to be shared at least 50% by industry and perhaps up to 2/3, depending on competitive interest.

VI. POTENTIAL PROBLEMS

In view of the enthusiastic support from utilities, fuels industry, power industry, and Government, there appears to be no direct institutional, economic, or side effects problems from the advanced power cycle. Widespread acceptance

Figure 5. ADVANCED POWER CYCLE



of an economic and healthy coal mining industry. Thus, problems facing the industry, such as, financing of the large investments for mine development and expanded production, recruitment and training of new employees, and developing environmental controls of mine acid waste and strip mining reclamation must be solved to permit the growth of the industry.

VII. ORGANIZATION AND MANAGEMENT

The program effort will require the contractor to possess broad and diverse technical disciplines, background, and experience in power generation, chemical process technology, and utility systems - capabilities not at all likely to found in a single industrial corporation. Consequently, the industrial participation should consist of a team effort comprised of: a power equipment manufacturer with development experience in gas and steam turbines; chemical processing company or fuel supplier with developmental experience in gasification and desulfurization; electric utility to furnish site, electrical distribution, and operating personnel; and, optionally, an architect-engineer to provide detailed plant engineering and construction management.

EPA would retain overall program management and direction and shall coordinate the program with other on-going gasification programs sponsored by Federal agencies and industry. One member of the industry team shall serve as the prime contractor with responsibility for assuring performance of technical and financial obligations of the other participants.

United Aircraft Research Laboratories



December 16, 1971

The Honorable Henry M. Jackson, Chairman
Committee on Interior and Insular Affairs
The United States Senate
Washington, D. C. 20510

Reference: Your letter of November 30, 1971 to Mr. P. A. Stranges

Dear Senator Jackson:

In response to your referenced request, attached hereto for the record is a summary of findings from the analysis recently completed by the United Aircraft Corporation Research Laboratories for the Environmental Protection Agency. The subject of this analysis was the technical and economic feasibility of advanced power cycles employing coal gasification for utility power stations. Briefly, the results of this analysis indicate that there are no technical constraints on building advanced electric power stations which would essentially eliminate the air and water pollution problems of the utilities, and simultaneously produce lower cost power than projected conventional fossil or nuclear steam stations. These advanced electric power stations will require the combination of gas turbine, steam turbine and fuel gasification technology in an integrated system. To bring this system to fruition, these various separate but well-understood technologies should be demonstrated together as an operable power system at the earliest possible time.

During this analysis, particular attention was directed to coal gasification to provide clean fuel gas of low heating value in the 150-175 Btu/cu ft range. Such fuels appear particularly well-suited for large-volume use by electric utilities, since the incremental cost of producing such fuels is estimated to be approximately one-third to one-half of that for pipeline quality gas (950-1000 Btu/cu ft) from coal.

During the period of approximately one year since our completion of the EPA-sponsored analysis, Corporate-sponsored analyses in this subject area have continued. Therefore, a brief summary of these subsequent analyses, together with a recommended future plan of action based in part on these analyses, is also attached herewith for your use.

We appreciate your interest in this work and thank you for the opportunity of providing these summaries and recommendations.

Sincerely yours,

UNITED AIRCRAFT CORPORATION
Research Laboratories

Charles M. Kearns, Jr.
Charles M. Kearns, Jr.
Vice President for Research

afm
Akk

The Technological and Economic Feasibility of
Advanced Power Cycles and Methods of Producing
Nonpolluting Fuels for Use in Utility Power Stations

The Research Laboratories of United Aircraft Corporation, under Contract CPA-22469-114, from the Office of Air Programs, Environmental Protection Agency, performed an analysis of the technological and economic feasibility of advanced power cycles and methods of producing nonpolluting fuels for use in utility power systems. The objective of the study was to define methods of desulfurizing readily abundant fuel, such as high-sulfur residual oil and high-sulfur coal and identify advanced, high-performance utility power systems whose increased efficiencies and reduced capital costs would offset the cost of fuel investment and thus allow electric power to be generated at the lowest cost. The following paragraphs summarize the study reported in detail in Ref. 1.

The technical approach was based upon technology currently available, but possibly not yet reduced to commercial practice, as well as technology judged attainable for commercial use within the next ten and twenty years. For convenience, these are referred to as first-, second-, and third-generation systems, respectively. This approach included evaluations of current and projected fossil-fuel desulfurization and conversion processes, current and advanced-cycle central power stations, and integrated fuel cleanup and power stations. FMC Corporation performed the evaluation of the fuel processing systems including the selection of representative fuels; consideration of the form of the converted fuel; definition of the technology necessary to realize economic, large-scale conversion of fuels; and an indication of the economic benefits that could arise from potential by-product sales. The United Aircraft Research Laboratories and Burns and Roe, Inc., investigated the technical and economic feasibility of advanced-cycle central power stations designed to utilize clean fuels.

Detailed consideration was given to integration of the fuel cleanup processes and power stations. An investigation was conducted to select the combinations of fuel cleanup process and power station capable of producing lowest-cost power. Fuel cleanup process flow diagrams and power station component layout drawings were prepared as were layout drawings of the integrated stations. Detailed capital cost estimates and estimates of the annual owning and operating costs were made for the selected integrated stations.

Conclusions of Investigation

1. Coal and residual oil fuel cleanup processes have been identified which could reduce sulfur content to levels equivalent to, or below, those required to meet both the near-term EPA goal of 1,000 ppm sulfur-oxide pollutants in the combustion product effluent, and the ultimate goal of 50 ppm.

2. Advanced-cycle power systems have been identified which could operate at efficiencies sufficiently high to more than compensate for the higher costs of the clean fuels, thereby resulting in projected busbar power costs lower than costs from current, conventional steam stations that pollute the atmosphere.
3. The hydrodesulfurization of residual fuel oil can produce a fuel which would meet the near-term EPA sulfur oxide emission goal of 1,000 ppm in the stack gas. However, this fuel, which can be considered a first-generation clean fuel, would be unsuitable for use in advanced-cycle power systems since the combination of metals content and residual sulfur content would cause extensive corrosion at the temperatures likely to be encountered either on heater tube walls or on turbine blades. Hydrotreating to levels of sulfur content corresponding to ultimate EPA emission goals would make the resulting product uneconomical for use as a power plant fuel.
4. The gasification and desulfurization of coal to meet EPA sulfur oxide emission goals could be accomplished with commercially available equipment, e.g., a Lurgi-type dry-ash gasifier in conjunction with a hot-potassium carbonate scrubbing system. The higher cost of clean fuel from this system would result in increases in busbar power cost from first-generation power stations compared with current conventional power stations.
5. Advanced second- and third-generation coal and oil cleanup systems could be developed with existing fundamental technology for high-temperature elevated pressure gasification of coal and residual oil followed by commercially available sulfur-scrubbing techniques to remove all except one percent of the sulfur contained in the original fuel.
6. While the clean, gaseous fuel from such systems would have a heating value of only 150 to 200 Btu/scf (natural gas has 950 to 1050 Btu/scf), the gas would be suitable for use in advanced-cycle gas turbine power systems. The incremental cost of preparing the lower Btu fuel gas would be approximately one-half of that of preparing a synthetic natural gas from coal.
7. During the next ten years advanced-cycle power stations utilizing combined gas and steam turbine (COGAS) power systems and burning a gasified and desulfurized fuel have the potential of not only reducing the emissions of sulfur oxides by over 99 percent compared to present-day conventional power stations, but also of producing electric power at costs significantly lower than those of present-day conventional power stations.
8. Technology currently being developed for advanced aircraft gas turbine engines will suffice for the development of commercial base-load utility gas turbine systems with unit capacities as high as 500 Mw. Although such equipment is not now available, its development would be evolutionary

and would not require significant technical breakthroughs to reach fruition.

9. Advanced-cycle base-load gas turbine power stations burning a gasified and desulfurized fuel also have the same potential for sulfur oxide reduction and, while not as attractive as COGAS systems, would have the potential of producing power at costs which are lower than those of present-day conventional steam power stations.
10. Conventional fossil-fueled steam stations will not display significant increases in station efficiency over the next two decades. The cost of electric power from such stations, were a clean desulfurized fuel to be used, would increase significantly compared to the current cost.
11. Other advanced-cycle systems, such as those using liquid-metal topping cycles, ammonia or fluorocarbon bottoming cycles, or closed-cycle gas turbines, while demonstrating station efficiencies comparable to or higher than those of conventional steam stations, do not offer the potential of reduced power costs.
12. Advanced-cycle power stations based upon COGAS or base-load gas turbines have the potential of significant reductions in both thermal pollution and in nitrogen oxides pollution.

Recommendations

1. A demonstration plant consisting of a COGAS power system and an advanced state-of-the-art coal gasification system should be constructed at the earliest possible time. Such a pilot plant would demonstrate the advantages in operating efficiency and power cost that could be realized by advanced-cycle COGAS systems. A study program with the objectives of defining the performance and identifying modifications to current equipment that would be required to construct such a plant should be undertaken as soon as possible.
2. A program should be undertaken to develop an air-blown, high-temperature, elevated-pressure, entrained-flow gasifier that would produce a low-heat-content fuel gas suitable for use in advanced-cycle power stations.
3. Process improvements for the removal at high temperature of sulfur compounds and particulates generated by gasification processes should be energetically pursued.

4. Research and Development programs should be undertaken to hasten the appearance of advanced materials and cooling techniques which would allow the introduction of advanced-cycle gas turbines operating at turbine inlet temperatures above 2,500 F in a base-load application.

Synopsis of Study

Fuel Desulfurization Process

The processes considered for coal conversion were: physical processing, including mechanical separation; chemical processing, including deashing, coal extraction, and pyrolysis; gasification, including the Lurgi-type dry-ash process, partial-oxidation with slagging, molten salt process, and the carbon dioxide acceptor (dolomite) process; and chemical desulfurization processes, including a liquid acceptor process. The processes considered for oil conversion were: hydrotreating, gasification, coking with coke gasification and desulfurization, and catalytic oxidation of sulfur.

The above coal and oil conversion processes were evaluated for three technological levels. Technology currently available, although not necessarily reduced to commercial application, technology judged to be attainable within ten years, and technology judged to be attainable within twenty years. These levels of technology are called first-generation and second-generation technology, respectively.

For the purposes of this study, a power system with a nominal capacity of 1000 Mw was selected as the basic unit for comparing costs of different fuel processes. Thus, the size of a fuel processing plant would be roughly defined as being sufficient to supply fuel to a 1000-Mw power system. However, the actual size of the fuel processing plant would depend upon the power system efficiency which, in turn, would be a function of the type of fuel being delivered, the particular power cycle selected, and the level of technology used.

Initially, the study goals were set by the EPA for sulfur emissions in ppm of SO_2 in the stack effluent; 1000 ppm for 1970 technology, and 50 ppm as the ultimate goal. However, this measure depends on the amount of excess air required for combustion and would create an artificial advantage for gas turbine systems. Another criterion for sulfur emissions is the weight of sulfur per unit of fuel consumed, grams per million Btu, adjusted to a constant amount of excess air. This criterion was used for all comparisons of alternative fuel desulfurization processes. Sulfur emissions of selected processes were also compared per unit of power generated, grams per kwhr, in order to include improvements in pollution abatement due to efficiency improvements in energy conversion.

Initially, these criteria were set at 450 g/million Btu for first-generation processes (1000 ppm SO₂); 90 g/million Btu for second-generation processes (200 ppm SO₂); and about 20 g/million Btu for third-generation processes (50 ppm SO₂). Included in the above estimates was the equivalent amount of sulfur emitted from the fuel processing, so that the total sulfur emission was taken into account. Preliminary work was based on these guidelines.

As the study developed, however, it became apparent that the above guidelines were unrealistic. Certain processes were inherently capable of removing a certain amount of sulfur, and it made no sense to try to operate them to remove much less sulfur, or much more sulfur, simply to satisfy the arbitrary guidelines. Therefore, the guidelines were dropped, and each process was analyzed on the basis of removing all of the sulfur that could reasonably be removed, regardless of time period for which the process was considered. The ultimate goal of about 20 g/million Btu was kept in mind, however, as a qualitative guideline, when processes were judged.

The gasification of coal or residual oil in air-blown, elevated-pressure, and temperature gasifiers followed by liquid scrubbing in any of several commercially available sulfur removal processes appears to offer the most promising method of delivering a fuel low in sulfur to advanced-cycle power systems at reasonable cost. For first-generation use, only the Lurgi-type fixed-bed, nonslagging gasifier would be commercially available. However, by the mid-1970's, later-generation fuel processing systems could use slagging, entrained-flow gasification vessels which could further reduce both the investment and annual costs of the system. The costs of the fuel delivered to the power system would be a function of power plant efficiency, sulfur level in the fuel, time period considered, and several other factors; however, the estimated incremental costs for clean gaseous fuel range from 20 cents to 30 cents/million Btu over the cost of the untreated fuel used as feedstock.

Advanced Power Systems

A review of current conventional steam power station technology was made to establish a basis for projections of future technology for this type station. The current and projected steam power system technology formed the basis against which all other advanced-cycle power systems were compared. Pertinent design specifications were determined for those systems judged to have the potential of generating power at busbar costs competitive with conventional steam power systems. Detailed economic characteristics of these selected advanced-cycle power systems were defined and estimated busbar power costs compared.

The advanced-cycle power systems considered can be placed into two generic groups:

External Combustion

Conventional steam-electric
Topping and bottoming cycles
Closed-cycle gas turbine

Internal Combustion

Open-cycle gas turbine
Combined gas turbine-steam turbine

More specifically, the power systems investigated included: conventional steam power systems burning both treated and untreated coal and residual oil; potassium topping cycles and ammonia and fluorocarbon bottoming cycles; closed-cycle gas turbines with helium, carbon dioxide, and sulfur dioxide working fluids; simple-cycle gas turbines, and gas turbines with regeneration; and a variety of combined gas and steam (COGAS) systems. For the purposes of this study, a power system with a nominal capacity of 1000 Mw was selected as the basis for comparing performance and costs.

The use of large industrial-type gas turbines utilizing aircraft-based technology in combination with a waste-heat recovery steam system appears to offer a means of generating electric power at busbar costs competitive with conventional untreated coal- or oil-fired steam systems even when burning a relatively high-cost desulfurized fuel. A first-generation combined gas and steam (COGAS) system would be competitive with conventional steam stations burning untreated fuel only at desulfurized fuel costs in the lower range of projected costs, but second- and third-generation COGAS systems would be competitive over a wide range of fuel costs.

Projected second- and third-generation simple-cycle gas turbine systems also appear to offer the promise of generating lower-cost power than the conventional untreated coal- or oil-fired conventional steam power systems. While the projected busbar costs for base-load power from this type of system are not as attractive as those projected for the COGAS systems, a decrease in station load factor, high interest rates, and consideration of cooling water shortages would make the busbar cost of power from the gas turbine systems more attractive than that of the COGAS systems.

The above gas turbine and COGAS systems are based upon the attainment of turbine inlet temperatures of 2200 F and higher. Such temperatures can be attained if current aircraft technology in the fields of materials and blade

cooling techniques is applied. In order to reach the 2800 F and 3100 F temperatures projected for second- and third-generation systems, the compressor bleed air used for cooling the turbine blades must be precooled to approximately 200 F in external heat exchangers before injection into the turbine section. This precooling would allow smaller bleed flows for a given temperature or a higher temperature for a given bleed flow. In either case, turbine performance would be enhanced.

Although several of the topping cycles and closed-cycle gas turbine systems offer significant improvements in performance over that projected for the conventional steam-power systems, the estimated capital costs for these systems, all of which required large amounts of high-nickel steels or refractory materials, were quite high. Thus the projected busbar costs were not as attractive as those for the COGAS and gas turbine systems.

Synopsis of Results

An advanced-cycle power station using a COGAS power system fueled by a partial oxidation, entrained-flow, high-temperature gasification system has the potential of generating electric power at busbar costs significantly below those projected for conventional steam power stations while reducing sulfur oxide emissions by over 99 percent. First-generation, advanced-cycle power stations using a COGAS power system would not be competitive in busbar power cost with conventional polluting steam power stations but would offer approximately 85 percent reduction in sulfur oxide emissions.

Advanced-cycle power stations using base-load gas turbines fueled by partial oxidation type, entrained-flow, high-temperature gasification systems would also be capable of producing electric power at busbar costs below those projected for conventional steam power stations. While the cost of power would be somewhat higher than that projected for COGAS systems, significantly less capital investment would be required for gas turbine stations. Consequently, for operation at reduced load factors (below approximately 50 percent for second- and third-generation), gas turbine power stations would have the potential of generating the lowest-cost power.

All advanced-cycle gas turbine and COGAS power stations considered would incorporate cooling towers, where needed, in both the fuel processing and power systems; thus, these stations would emit essentially no thermal pollution.

Subsequent Analyses

Upon completion of the EPA-sponsored analysis, it was readily apparent that the use of gasified coal or residual oil-fired COGAS power systems have a potential for reducing air pollution yet allowing use to be made of this country's large reserve of coal. The study for EPA was based on projected technology judged attainable within the next 20 years. Based on the results of this study, it appears that by the start of the 1980 decade advanced combined COGAS power systems will certainly have the potential of reducing sulfur oxide emissions by 99 percent compared to present-day conventional power stations and simultaneously producing electric power at lower costs. Subsequent Corporate-sponsored studies were carried out with the objective of assessing the near-term (1975) attractiveness of such systems.

Estimates were made of the pollution characteristics as exemplified by the emissions of SO_2 and NO_2 , in lb/Mwhr, from base-load conventional steam and COGAS systems. The busbar cost of power was estimated for the standard coal-fired conventional steam station with (a) no pollution control, (b) with stack gas cleanup, (c) a gasified coal-fired steam station meeting all pollution regulations, and (d) a currently available COGAS system burning distillate oil or gasified coal.

The pollution characteristics are summarized in Table I. From this table it can be concluded that, while the near-term SO_x and NO_x EPA limits can be met by the combination of low-sulfur fuel with stack gas cleanup and the use of staged combustion, the gasification of coal or residual oil could result in emissions which are well below the near-term requirements and which could comply with the more stringent urban standards which are in effect in some U. S. cities. Representative busbar costs based on constant 1970 dollars are also shown in Table I. While these costs are quite dependent on localized conditions such as fuel costs, local pollution regulations, and individual utility practices, in general they indicate that the gasified coal- or gasified residual oil-fired systems offer an economic advantage over the other methods of pollution abatement.

Analysis has indicated that the use of the low-Btu fuel gas should significantly reduce the emission of nitrogen oxides. While the exact reductions must be verified experimentally, factors of 10 or more are possible. These values are reflected in Table I.

Recommended Future Plan of Action

The major recommendation from the EPA-sponsored study is that a demonstration plant should be built at the earliest possible time. In the year that has elapsed since the completion of this study, it has become more imperative that

such a demonstration plant be built. The supply of inexpensive energy in this country is no longer available. Fuel costs have soared so that it becomes an economic necessity to achieve high efficiency in converting fuel to (electrical power. The fact that these high efficiencies can be achieved in conjunction with significant reductions in the emission of sulfur dioxide, the oxides of nitrogen, particulates, and in the thermal pollution of our waterways, underscores the need to demonstrate this technology at the earliest possible time.

With this in mind, United Aircraft Corporation has proposed a plan of action which could lead to the operation of a commercial-scale, nominal 125-Mw demonstration plant in the first or second quarter of 1975. A milestone chart for this plan is shown in Table II. The preliminary phases of this work, which would include testing of the combustion characteristics of the low-Btu gases, are currently under way. Accurate cost estimates for the demonstration program will not be available until the preliminary design phase of the study is complete; however, it is projected that \$40 to \$50 million would be required. This cost includes a large amount of research and development work which would be required for the initial demonstration unit as well as operating costs for a one-year demonstration period. Subsequent installations would be significantly less expensive. United Aircraft is currently seeking utility participation in the funding of such a program and is, of course, cognizant of the interest in both the EPA and the Department of the Interior in such a plant.

Reference

- Robson, F. L., et al.: The Technological and Economic Feasibility of Advanced Power Cycles and Methods of Producing Nonpolluting Fuels for Use in Utility Power Stations. United Aircraft Research Laboratories Report J-970855-13, December 1970.

TABLE I
COST AND POLLUTION CHARACTERISTICS OF PROSPECTIVE BASE-LOAD POWER SYSTEMS
Present-Day Technology

Power System Option	Power Cost (1) mills/kwhr	Sulfur Oxide (2) Emissions, lb/Mwhr	Nitrogen Oxide (3) Emissions, lb/Mwhr
Steam System - Coal			
Proposed 1975 EPA limit (4)	---	11.2	6.5
Typical Coal	7.2	55-65	10-20
Low-Sulfur Content	10.0	15-20	10-20
Coal with Stack Gas Cleanup	8.7	12-17	10-20
Low-Sulfur with Stack Gas Cleanup	11.5	3-5	10-20
Low-Sulfur with Stack Gas Cleanup and Off-Stoichiometric Combustion	11.7	3-5	2-4
Gasification	9.9	0.5-1.0	0.1-0.5
Steam System - Residual Oil			
Proposed 1975 EPA limit (4)	---	7.4	2.8
Typical Oil	6.8	25-30	3-8
Low-Sulfur Content	9.6	10-15	3-8
Low-Sulfur with Off-Stoichiometric Combustion	9.8	10-15	0-7.2
Gasified Oil	9.2	0.5-1.0	0.1-0.5
Steam System - Natural Gas			
Proposed 1975 EPA limit (4)	---	nil	1.8
Gas	7.4	nil	3-14
Off-Stoichiometric Combustion	7.6	nil	1-2
COGAS System (5)			
Distillate Oil	12.0	2-4	8-11
Natural Gas	7.7	nil	5-8
Gasified Coal	9.6	0.5-1.0	0.1-0.5
Gasified Residual Oil	8.5	0.5-1.0	0.1-0.5

- (1) Coal and residual oil at 30¢/million Btu, natural gas at 40¢/million Btu, and distillate at 90¢/million Btu.
 (2) Expressed as sulfur dioxide, SO₂
 (3) Expressed as nitrogen dioxide, NO₂, although primary emission is nitric oxide, NO
 (4) The proposed EPA limits are given in emissions/million Btu fuel burned and thus must be multiplied by the station heat rate to obtain the value shown. More stringent limits are in effect in several large urban areas.
 (5) Based upon current commercially available combined-cycle systems

TABLE II

PRELIMINARY SCHEDULE FOR DEMONSTRATION PLANT

