DEPARTMENT OF THE INTERIOR PROGRAMS FOR CONVERSION OF COAL TO GASEOUS AND LIQUID FUELS

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I am sure that all of us in this room are aware of the energy problems facing this Nation. Our problems, however, are not caused by shortages of energy as such, but by shortages of energy in the clean and convenient gaseous and liquid forms in which we prefer to utilize it.

To meet our coming needs all domestic energy resources--coal, oil, gas, oil shale, tar sands, and atomic energy--must be developed as rapidly and completely as possible. Coal, of course, is the greatest energy resource in the contiguous 48 States, but for reasons of inconvenience and environmental pollution its percentage of total market has fallen steadily over the past years. The coal conversion program of the Department of the Interior is directed toward reversing that trend.

Coal conversion is nothing new. Hydrogenation of coal, frequently referred to as the Bergius process, is about 60 years old and the Fisher Tropsch synthesis--in simple terms, partial combustion of coal with oxygen and reaction with steam to produce a synthesis gas--is almost as old. Similarly, modern chemical process technology was built on the recovery of coal tar dyes, an outgrowth of modern (this century) steel making. At various times during and since the 1920's, apparent shortages of petroleum led to increasing emphasis on conversion of coal to oil and to gas. Many of us can remember the local gas manufacturing plants in many American cities. Coke ovens, too, were operated to produce merchant coke and by-product gas for domestic use.

In World War II, Nazi Germany fueled its war machine with synthetic fuel produced from native coal. During the later days of the war, the U.S. Congress established a synthetic fuel program in the Department of the Interior that led to construction of the Louisiana, Missouri plant and the oil shale processing plant at Rifle, Colorado. This program produced much valuable and useful engineering information, but large-scale discoveries of petroleum in the Middle Fast and the projected costs of the oil produced led to termination of the work.

The key element of Interior's clean energy from coal program is the conversion of coal to high-Btu pipeline gas. We are investigating four processes which are sufficiently different to require testing at a pilot plant scale. The first three projects relate to the President's Clean Energy Message of June 4, 1971, and are part of an accelerated Interior-American Gas Association program directed toward development of data for design of a demonstration plant by the summer of 1975. The total estimated cost for this work is $120 million, with $40 million provided by the gas industry and $80 million provided by Government.

Since this Government/Industry agreement is unique and possibly a breakthrough in cooperative research efforts, I shall describe it more fully.

The overall program will be constantly monitored and evaluated with the assistance of an independent, unbiased contractor. C.F. Braun & Co. of Alhambra, California, was selected for this task and has been actively engaged in it for the last several months.

As a result of continuing studies of the various processes and sub-processes as the pilot plant program continues, optimums will be discerned. These will serve as the basis for the engineering design of a demonstration plant to be built and operated largely through industry financing. This demonstration plant, expected to have a productive capacity of about 80 million cubic feet per day of pipeline-quality gas (900 to 1,000 Btu/ft) manufactured from approximately 5,000 tons of bituminous coal, will use commercial-scale equipment. Success of this program will provide, by the end of the decade, a sound commercial basis for the construction and operation by industry of large coal-based synthetic pipeline-gas plants.

The agreement with A.G.A. provides for one-third funding by that organization and states that ownership of all equipment, such as that contained in pilot plants, and patents remain in the Government. The research and development contracts are largely standard Government contracts, providing for a Government Contracting Officer, with A.G.A. reimbursing the Government for its share of the cost. All of the information developed during the course of the work will be published and will be available to the public.

Organization and procedures for overseeing the joint program have been agreed upon. An Operating Committee drawn from the OCR and A.G.A. staffs has direct supervisory responsibility for the various projects. Committee members will report to the two Program Directors--the Director of Coal Research (OCR) (normally the Contracting Officer) and the Director of Research and Engineering (A.G.A.). Ultimate authority is in a Steering Committee made up of the Assistant Secretary - Mineral Resources, Department of the Interior, the President of the National Academy of Engineering, and the President of the American Gas Association, Inc.

The accelerated parallel gasification development program is necessary to insure that at least one economically sound process is made available within the required time schedule. All of the processes have been demonstrated on a bench-scale to be technically feasible and all do essentially the same thing, but in different ways. Hydrogen is taken from water and combined with the carbon in coal to form methane. Some of the carbon is burned in air, or oxygen, to provide heat for the process so that carbon dioxide is a waste product. Ash and sulfur will also be removed--the latter as a salable or disposable byproduct.

The practicality and demonstrated economics of the basic gasification processes are unresolved at the present time. The pilot plant program will permit a determination of practicality and economics so that the demonstration plant can be designed with confidence. Probably the ultimate process will be made up of unit operations selected from several of the pilot plants.

The gasifier is the basic unit in each process, operating at pressures ranging from 300 to 1,000 pounds per square inch and temperatures varying up to 2,800° F. Various methods of feeding solid coal into this high-pressure, high-temperature vessel will be investigated, including slurry pumping and lock hoppers. All of the gasifiers will produce a "synthesis gas," a mixture of hydrogen and carbon monoxide, and as much methane as possible, together with impurities such as carbon dioxide and sulfur gases.

The HYGAS pilot plant has been built by the Institute of Gas Technology in Chicago, Illinois. Many mechanical and startup difficulties have been encountered.

It has been necessary to make many relatively minor changes to obtain satisfactory operation. A great deal of trouble has been caused by the malfunction of "standard" equipment such as compressors. All problems encountered to data have been solved but it is a slow and expensive process. One must realize that to shut down the gasification reactor to make any equipment change and then restart takes about 2 weeks.

Here is just one example. Because of many months' problems with the main hydrogen compressor, it was never possible to achieve a sustained gasifier run at the designed pressure of 1000 psi. Finally, the compressor problem was licked (by lubricating the last stage) and a sustained run started. Then some reactor internal valve operating mechanisms, which had been quite satisfactory at lower pressures, became inoperable, and it became necessary to again shut down to change valve operators. Recently, we have had our first successful operational run, and we expect engineering design data to start to be derived from the plant operation during the remaining months of this year. A little later on we will expect to consider the addition of an electrothermal gasifier, which acts as a source of hydrogen for the process. Engineering data for the design of a commercial-scale plant based on its operation are expected to be obtained during 1973.

The CO_2 Acceptor pilot plant has been constructed by Stearns Roger for the Consolidation Coal Company at Rapid City, South Dakota, and is now undergoing shakedown tests. We anticipate engineering to be available for design of commercial facilities by the end of 1973.

Our BI-GAS pilot plant will be built by Bituminous Coal Research, Inc., at Homer City, Pennsylvania, and should be in test operation in about 2 years. Design data for that process are expected by the middle of 1975.

The fourth high-Btu coal gasification pilot plant will be constructed by the Bureau of Mines at Bruceton, Pennsylvania, and it, too, should be operational in about 2 years. That plant is an integral part of the Department of the Interior's program and will be evaluated by C.F. Braun & Co., but is not a part of the accelerated Interior-American Gas Association program.

The three OCR pilot plants (Chicago, Rapid City, Homer City) will represent a total investment of $45 million by the time they are completed. This is one reason for growth of our budget from $1 million in 1961 to today's $45 million. Experimentation at this scale, about 1 to 5 tons per hour, is costly, but it must be undertaken if practical processes are to evolve from the research and development effort.

Clean Energy, Fuel Gas

The OCR budget includes work on the development of a low Btu fuel gas using a fluidized-bed and an entrained-bed gasifier. Logically, this work builds on the fluid-bed and entrained-bed work we are doing in the development for high-Btu pipeline gas.

Both pilot plants will be designed to handle about 50 tons of coal per hour. Each unit will be experimental and designed to operate over a range of pressure, perhaps 50 to 500 pounds per square inch. The units will have a capacity ranging from about 25 to the maximum of 50 tons per hour. These capacities are about ten times the capacity of the pipeline-quality gas pilot plants.

Each plant will include a low temperature (less than 1000° F.) gas cleanup system which will remove sulfur as well as particulate material from the gas. Also, we will be seeking methods to clean the gas at high temperature (above 1000° F). The process of converting coal to a clean fuel gas will be much improved if a cleanup system is developed to operate at gasifier temperature.

Further down the road, we hope to integrate the gasification and cleanup system with a combustor followed by a gas turbine and a waste heat boiler raising steam to drive a steam turbine. It should be pointed out that this program has been chosen to encourage public utilities and coal companies to participate in financial support for the program.

Clean Energy, Fuel Oil

The President's Clean Energy Message of June 4, 1971, mentioned clean liquids from coal as well. The OCR program includes investigations to convert coal as well. The OCR program includes investigations to convert coal to oil by the direct hydrogenation of coal and the extraction of coal followed by hydrogenation of the extract. This portion of the program is expected to produce a fuel oil that will meet all projected air quality regulations.

Prior to the suspension of work at the Cresap Pilot Plant, the extract production operations had been demonstrated with both startup and process-derived solvents using Pittsburgh seam coal for periods of sufficient duration to establish process operability and yields at conditions approximating those suitable for commercial design purposes.

Mechanical problems prevented a satisfactory demonstration of the yields and process operability in extract hydrogenation; the longest uninterrupted operation of 5 days' duration was carried out at operating conditions far from optimum.

A detailed engineering survey of the pilot plant was made by Foster Wheeler Corporation under a separate OCR contract. It was concluded that the process was technically feasible, but that certain modifications of the pilot plant were necessary to improve mechanical reliability. Similar conclusions were reached by a Committee of the National Academy of Engineering under a separate evaluation study.

Because of the critical and growing need for low-sulfur utility fuels in the Eastern United States, we are considering adapting the Cresap facility to produce primarily low-sulfur fuel oil from Eastern high-sulfur coals.

Project COED (Char-Oil-Energy-Development) has been under development with the FMC Corporation at Princeton, New Jersey, since 1962. It is a process for converting coal by multistage, fluidized-bed pyrolysis of the coal to produce char, oil, and gas. The pyrolysis-derived oil is also hydro-treated to produce a valuable synthetic crude oil.

The pilot plant is designed to process 36 tons of coal per day and hydrotreat 30 barrels of coal-derived oil per day. It is fully operational at the throughput capacities of coal and oil for which it was designed. Experimental programs in process variables, process equipment modifications, and coal evaluations are now underway.

Projected economics for a commercial COED plant are encouraging for certain geographic areas. The concept, however, has additional value when viewed as a part of, or adjacent to, other processing plants such as gasification or direct energy processes, which can utilize and further upgrade the products or produce energy directly.

Groundbreaking ceremonies for the Pittsburg & Midway Coal Mining Co.'s Solvent Refined Coal pilot plant at Tacoma, Washington, are to be held on October 27, 1972. The 50-ton-per-hour plant was designed by Stearns Roger Corporation.

In the solvent refining process, coal is first dissolved in a heavy aromatic solvent under moderate hydrogen pressure. The solution is filtered to remove ash and a small amount of insoluble organic material and is then fractionated to recover the solvent. Small quantities of hydrocarbon gases and light liquids are produced, along with a heavy organic material called Solvent Refined Coal which has a melting point of about 350° F and contains about 0.1 percent ash and less than 1 percent sulfur. Its heating value is about 16,000 Btu's per pound regardless of the quality of the coal feedstock. The solvent refining process removes all of the inorganic sulfur and 60 to 70 percent of the organic sulfur in the coal.

The COG (Coal-Oil-Gas) Refinery

Coal can be converted to both oil and gas by somewhat similar processes. A gas process inevitably produces some "oil" and all liquid processes produce gas. During the past year, Chem Systems, Inc., working as a subcontractor to the Pittsburg & Midway Coal Mining Co., studied a number of processes in combination with others. This study produced the concept of a potential Coal-Oil-Gas (COG) refinery. The COG refinery is a combination of Solvent Refined Coal with the BI-GAS process.

This projected plant contains a number of significant features which include:

1. All products from the plant are energy forms.
2. Plant output can be varied, within rather wide limits, from year to year and season to season (more oil in the summer; more gas in the winter).
3. All waste products produced in the processing of the coal leave the system in the form of slag, thus no major environmental disposal problem is created.
4. The use of oxygen integrates well with the cryogenic gas purification separation system to make this low temperature section more efficient.
5. All products from the plant are nonpolluting.
6. The plant can be integrated with a powerplant.

The COG refinery includes a number of process steps:

1. The solvent refined coal process, which is the primary coal conversion step where coal is dissolved in the presence of a process solvent and hydrogen at 825° F and 1,000 psi.
2. Hydroconversion and Hydrocracking. The solvent refined coal is upgraded to a light refinery liquid.
3. The Bituminous Coal Research Bi-Gas Process, which serves as a source of hydrogen for the refinery, produces some methane, and disposes of all the heavy liquid produced in the refinery.
4. Shift Conversion. This process shifts the CO in the BI-GAS reactor effluent with steam to produce hydrogen.
5. Acid Gas Removal. Conventional hot K_2CO_3 processes remove CO_2 and H_2S from the BI-GAS effluent.
6. Conventional Methanation. A significant feature is the use of methanation only to remove residual CO much as it is used in steam methane reforming plants today.
7. Cryogenic Separation. This low temperature separation is required to produce a 95 percent H_2 stream for hydroconversion and hydrotreating. Methane is recovered here as the pipeline gas product. LPG produced in various sections of the COG refinery is also recovered in this section.

This refinery requires a total feed of 57,700 tons of coal per day; 7,740 tons of oxygen, and will produce approximately 1,800 tons of sulfur; 7,660 tons of pipeline gas; 1,980 tons of LPG; 14,660 tons of light refinery liquid; 8,850 tons of solvent refined coal for plant use; and 2,500 tons of solvent refined coal as product. Additionally, 156 tons per day of chemicals will be manufactured. Thus, of nearly 1,500 billion Btu's per day, 1,400 billion Btu's are accounted for -- 93.5 percent of the Btu's fed to the plant. 277 billion Btu's are used as plant fuel, so that the net thermal efficiency of the process is 68 percent.

Potentially, subsequent to 1982, or thereabouts, one trillion cubic feet per year of new capacity may be added to the synthetic gas capacity with a concomitant production of one-third of a billion barrels of oil. If the figures for the COG refinery are correct and remain constant, we are talking about total new investment in the order of $8 billion per year in mine and physical plant. This is a staggering sum, but somehow the oil and gas industry will rise to the challenge and coal refineries producing clean energy forms will be built in Appalachia, in the Mid-continent, in the Northern Plains, and in the Intermountain West.