Coal Research (I): Is the Program Moving Ahead?

Coal occupies a unique position among U.S. energy resources. We have lots of it, at least 1.7 trillion tons—potentially more energy than all the remaining petroleum, natural gas, oil shale, and tar sands in the country combined. But coal is a dirty, inconvenient fuel for most uses, and the means to clean it up or convert it to other fuels are not far advanced, despite years of federal research programs and the expenditure of hundreds of millions of dollars. Equally unresolved are the environmental and social problems of mining coal, problems that would be exacerbated by a greatly expanded use of this material. Nonetheless, in the face of a growing shortage of natural gas and rising oil imports that now exceed 40 percent of U.S. consumption, coal appears to be a greatly underutilized resource.

The problem is only partly a lack of technology. Techniques exist, for example, to convert coal into synthetic natural gas, to gasoline and other liquid fuels, and to clean up the emissions from coal-fired boilers, although there are substantial problems with some of these processes. A more fundamental difficulty is the high cost of clean energy from coal. Synthetic fuels especially, if made with existing processes, appear likely to cost nearly twice the highest prices now paid for oil and gas. Uncertainties about environmental and regulatory policies, about the intentions of the oil exporting countries, and about the degree of political support for federal assistance in launching whole new industries are also major deterrents to a wider use of coal. Indeed, many observers agree with Eric Reichl, a leading coal scientist and president of Continental Oil's coal development company, that "the problem of coal conversion is much more a political and economic issue than it is a technical one."

In any case, no synthetic fuel plants based on coal are being built in the United States at present; official estimates of the synthetic fuel capacity on line in 1985 have been substantially reduced from the equivalent of 1 million barrels of oil a day (about 20 plants) to about one-third of that figure and are still widely regarded as overly optimistic under existing conditions. Nor is coal yet replacing oil and gas in electric generating plants. The Federal Energy Administration has ordered less than 75 power plants with a capacity of only 11,000 megawatts to switch back to coal, and even these orders have not yet gone into effect because of delays for environmental impact statements. Moreover, nearly 30 percent of the new fossil-fired power plants to be built in the next 5 years (approximately 95,000 megawatts) are to use oil or gas, according to Elburt Osborn, a former director of the Bureau of Mines now associated with the Carnegie Institution of Washington.

The coal research program of the Energy Research and Development Administration (ERDA) is designed to remedy these problems, or at least their technical aspects, by developing a new generation of coal processing techniques. These "second-generation" processes promise improvements in economics, efficiency, and reliability over existing processes, although these advantages have yet to be demonstrated, and they will make available a wider range of synthetic fuels and coal combustion techniques. The coal research program is growing rapidly, with expenditures of over $500 million planned in the coming fiscal year (FY77) and informal estimates of a $1-billion budget in the near future. ERDA officials are hopeful that equipment on a commercial or near-commercial scale will be demonstrated for as many as a half-dozen new liquefaction, gasification, and direct combustion processes by the early 1980's. They express the belief that, since most of the agency's work is contracted out to industrial concerns, these new technologies will take root there and rapidly sprout a full-fledged industry.

This is an optimistic picture, and interviews with a large number of coal scientists reveal widespread concern about whether the coal research program is in fact moving ahead. Nobody will say on the record that the program is in trouble, for fear of embarrassing their own institutions or damaging their relationship with ERDA. But in private many assert that the core of the ERDA program, which was largely inherited from the Interior Department's Office of Coal Research (OCR), is not technically sound. Even more important is the division of risk sharing and management control between government and industry. Many observers fear that as ERDA's program is now constituted, few companies will put up their share of the money to build demonstration plants. The consequences may be the failure of the coal R & D program, the critics say, leaving the United States facing the closing decades of the century without the technologies to make use of our coal resources.

ERDA officials seem to acknowledge the problems. George Rial, head of the fossil energy demonstration plant program, admits that ERDA's policy of requiring a fifty-fifty sharing of costs between industry and government is controversial and not yet proved. Philip C. White, ERDA's assistant administrator for fossil energy, says flatly that the OCR program was not soundly based and that ERDA will very likely shut down some of the older pilot plants, especially in the gasification program, or convert them to other uses. Raymond Zahradnik, head of coal process development, is quick to emphasize the changes that ERDA has made since taking over. These officials are optimistic that the problems can be overcome—an optimism that is not universally shared, however, even within the ERDA bureaucracy.

It is only fair to point out that any program as large as the coal R & D effort, which spans matters of concern to the oil, gas pipeline, and electric utility industries, is unlikely to please everybody. Moreover, most of the program's critics in the coal research community, even those who agreed to speak candidly only with a promise of anonymity, go on to say that they view White and his immediate lieutenants as technically competent and not entirely to blame for the problems they face. "White inherited a mess," was the way Seymour Alpert of the Electric Power Research Institute put it. "He didn't make the rules and he can't change them." Another observer referred to "those beleaguered people down there in Washington." But ERDA's fossil fuel research officials get low marks for going along with programs and policies that, the critics charge, make little sense.

The policy of fifty-fifty cost sharing, for example, was apparently imposed on ERDA by the Office of Management and Budget—it is not in the agency's enabling legislation, which provides for a more flexible approach. Nor have many of the OCR programs been canceled, apparently in part because of opposition from influential legislators in the affected states—"politically difficult" is how White describes the process. White's response has been to give closer scrutiny to new projects before they are started. "We have committed a lot of taxpayer's money to develop second-generation processes, and we will have to be more and more hard-boiled about new starts."

One result of the escalating demands of existing programs, however, is that money is extremely tight, with much of the program's future budgetary growth already committed. Many individual investigators and program directors are finding it hard to get funding for new ideas and they are concerned that the process of innovation not be shut off entirely. Some report that their problems in dealing with ERDA are compounded by its bureaucratic inefficiency—a year is said to be an average length of time to get a contract out of the agency—and by the relatively small proportion of staff people in the fossil energy division who have a technical background in coal research. "It is damn galling to sit in front of some guy who doesn't know the first thing about coal and try to explain your program," one administrator of an ERDA energy research center told *Science*. But these are clearly secondary to the issue of whether the R & D effort will accomplish its goal of launching new combustion and synthetic fuel technologies into commercial use.

In a talk earlier this year at the AAAS meeting in Boston, Reichl said, "With ERDA as the virtually sole sponsor of any major effort in the field, their responsibility for selecting a program which assures success . . . is enormous." Reichl went on to suggest that ERDA is not yet living up to its responsibility and should pursue a broader range of technical choices based more closely on past, largely German, experience. "The worst," he concluded, "would be to build plants that don't work." Reichl did not refer to any specific plants, but one mentioned by many observers is ERDA's liquefaction demonstration plant.

A request for proposals to build such a plant to produce clean boiler fuel from coal was issued in 1974 by the OCR. The project was designed with the oil industry in mind, but attracted only one serious response, a joint venture of Union Carbide and Chemical Construction Company (known as Coalcon) with the backing of a 14-member consortium. Despite the meager response, the project was funded as OCR's last act—almost literally at midnight, 17 January 1975, before authority passed to ERDA. The plant is nearly completely designed, but a decision to proceed with construction (for which costs are to be borne equally by ERDA and Coalcon) has been postponed until 1977. ERDA and some of the industrial backers are reconsidering the venture, which now appears to have both some unresolved technical problems and, because of costs sharply higher than estimated in the original bid, uncertain economic prospects. Critics describe it as "a disaster." White says he is optimistic the project will go ahead.

Whether Coalcon succeeds or not, the circumstances surrounding this first effort to demonstrate an advanced coal conversion technology illustrate the problems involved. Gulf Oil had expressed interest in a boiler fuel demonstration plant and, by virtue of its long experience with a coal conversion process widely regarded as technically promising, had been expected to bid for it. But, according to a report by the General Accounting Office,* Gulf officials declined to participate because they regarded the terms as giving the government too much control over the project. Other companies have also expressed

Oil and Coal: A Troublesome Mix

In seeking to develop new means of processing coal, the Energy Research and Development Administration is depending heavily on participation by private industrial companies and asking them to put up both money and technical know-how. But the involvement of many of these companies with coal extends far beyond research. The oil industry's connection to coal in particular is coming under scrutiny because oil companies own large portions of the nation's coal reserves and several of the largest coal producers. It should be noted that gas pipeline and electric utility companies also own a lot of coal, but the wrath of critics ranging from Arnold Miller of the United Mine Workers to Senator James G. Abourezk (D–S.D.) has been directed primarily at the oil companies. "Oil and coal don't mix" has become a catchphrase among those who favor limiting companies to ownership of a single energy source (horizontal as opposed to vertical divestiture, which is also being proposed).

It is also true, however, that much of this country's limited expertise in coal processing and a majority of the privately funded efforts to develop synthetic fuels are to be found in oil companies. Exxon, for example, claims to have spent over $50 million of its own money on a new coal liquefaction scheme known as the donor solvent process. Texaco has put considerable effort into a new coal gasification process based on partial oxidation of the feed material; originally developed and put into commercial use for gasifying heavy oil residues, the process has been tested with a wide range of coals. Under contract with the Office of Coal Research (now ERDA), Gulf developed a process known as solvent refining that is akin to liquefaction, and that the company is now seeking to put into commercial use. Other companies regarded by many observers as having special expertise are Continental Oil and Shell in gasification and Ashland Oil in liquefaction.

One does not have to be a defender of the oil companies to find a certain inconsistency in trying to break them up or limit their holding of coal on the one hand, and asking them to participate in developing new coal technologies on the other. Indeed, the attack on the oil companies seems to be having an impact on the research program. The 8 October 1975 Senate vote on breaking up the oil companies, in which the pro-divestiture forces recorded 45 votes, reportedly scared a lot of people in the industry and, according to Philip C. White, ERDA's assistant administrator for fossil energy, is affecting two key liquefaction projects, a view supported by other observers as well. Both Hydrocarbon Research, Inc., which is developing a process known as H-coal, and Exxon are reportedly having trouble finding backers for industry's share of the money to build large pilot plants.

Thus the dilemma, evident in much of the debate over synthetic fuels, divestiture, and the role of coal in the U.S. energy economy: Should the United States punish the oil companies for their alleged economic and technical monopoly and for what many observers regard as their past efforts to prevent meaningful coal research programs? Or should the country attempt to use the oil companies' expertise and economic might to bring coal and coal-based fuels more into the mainstream of U.S. energy supplies, if necessary by changing the rules and offering incentives to develop the necessary technology? It is a choice that is liable to be more and more pertinent as shortages of natural gas and our dependence on imported oil increase.—A.L.H.

*Report to the Senate Committee on Public Works, RED-76-81, General Accounting Office, 5 May 1976.

concern over ERDA's patent policies. According to Rial, these policies have recently been made more flexible.

Still others have questioned whether demonstration plants for coal liquefaction technologies are not premature. In testimony last year before the House Committee on Science and Technology, Exxon vice president W. T. Slick said, "commercially promising coal liquefaction technology is just moving into the early stages of large pilot plant development," and larger plants "cannot logically be considered until after successful large pilot plant testing. . . ." Slick suggests that demonstration plants are not necessary at all and in fact will only delay the process of developing new technologies by imposing an extra, and costly, step; he favors scaling up technology from a large pilot plant to a first commercial plant, provided government will share the risks involved.

Coal gasification is a second major area of research, and one in which industry appears more enthusiastic about participating in the ERDA program. Five companies submitted proposals to demonstrate methods of making synthetic natural gas, and ERDA last month awarded contracts for design of the plants to two of the entries. But gasification research appears to be closely coupled to the prospects for commercialization of the resulting technologies. Since these are expected to be only marginally more efficient and cheaper than existing gasification processes, industrial progress provides a relevant yardstick of their commercial chances.

Several commercial gasification plants based on existing technology have been announced but are presently in limbo. Escalating costs have made it nearly impossible to raise the money to finance them without regulatory changes and government assistance, according to the financial consulting firm of Dillon Read & Co. Congressional approval of such assistance in the form of loan guarantees has not been forthcoming, however. These "first-generation" gasification plants are widely seen as pioneering the uncharted political, environmental, and regulatory hazards of a synthetic fuels industry. If they do not go ahead, the prospects for the unproved second-generation processes may be poor indeed.

Reichl, although his firm is one of the winners of the design contracts for the demonstration plant, says, "The creation of a synthetic gas industry will not depend on the outcome of this R & D program" because "there is no way to reduce the cost of synthetic gas by R & D to such an extent that it would affect the political decision" to go ahead with synthetic fuels. He estimates, in fact, that the new processes will only reduce the cost of synthetic gas by about 10 percent, although ERDA's estimates are slightly more optimistic. Reichl believes that it is still feasible for a group of companies to put up the money to build a demonstration plant. Other observers believe, however, that it is doubtful whether companies will actually put up the $200 million or more that will probably be required for their share of such a plant if there is still no prospect of commercializing gasification technology when the decisions to go ahead will have to be made in 1978.

A more recent ERDA effort, to demonstrate gasification processes for use with industrial and electric utility boilers (low-Btu rather than pipeline quality gas), attracted still more proposals from industry, some 13 in all. But none of them included a major utility company as a participant, thus assuring, according to observers familiar with the utility industry, that the project will not lead to widespread adoption of the results, whatever its technical success.

The prospects look better in the area of direct combustion of coal, however. A novel fluidized bed boiler of a size applicable to generation of process steam or small amounts of electricity is to begin operation in Rivesville, West Virginia, this fall. If it works, commercial introduction could be rapid. At least one major boiler manufacturer, Foster Wheeler, has announced it will begin marketing and granting warranties on the boiler after 6 months of successful operation. ERDA is preparing to seek proposals for demonstrating a larger unit of the same type for use by electric utilities.

The OCR Legacy

For now, the demonstration plants for liquefaction, gasification, and fluidized bed combustion exist only on paper, and it is the smaller pilot plants that constitute the core of the coal R & D program at present—nearly all of those now in operation or nearing operation begun during OCR's 15-year reign. The OCR program has produced few outright failures. But "it is difficult to say that anything positive came out of the program," according to John O'Leary, a longtime observer who was director of the Bureau of Mines and is now head of New Mexico's Energy Resources Board. O'Leary points out that OCR was set up to aid the coal industry, not to solve a national problem, and that it quickly became "a token program." Other observers point to its domination by political influences that dictated such things as the location of plants for processing eastern coals in the state of Washington, and a leadership that, according to one senior ERDA official, "confused activity with progress." Confidence in many, perhaps most of the resulting processes is not high within industry and the technical community. This aura of failure was underscored by the fact that none of the four gasification processes for which pilot plants have been built were among the two chosen for design of the demonstration plant. Instead, the key elements of both of the winning processes were developed in England. Nonetheless, few of these older programs have been canceled, and the coal research program as a whole suffers from its association with the questionable technologies and policies inherited, and to some degree perpetuated, by ERDA.

Unsuccessful attempts to launch a synthetic fuels industry in the United States have been made twice before, in the 1920's and again following World War II. The first was abandoned after discovery of the large East Texas oil fields undercut any hope of commercial success. The second, which included about $100 million in federal R & D work and construction of several successful pilot plants at Louisiana, Missouri, between 1948 and 1953, was scuttled by realization of the magnitude of the vast Middle East oil reservoirs. Then, as now, the real problem with synthetic fuels is economic. Even with imported oil reaching the United States at around $12.50 a barrel (equivalent to $2.15 per million Btu's), coal-based fuels do not appear to be competitive. Most estimates are that synthetic oil and gas from coal will cost close to $4 per million Btu's.

For that reason the oil industry does not appear especially eager to move into synthetic oil without federal subsidy in some form, especially since imported oil is still readily available. The coal industry has shown even less willingness to develop coal-based synthetic fuels (and the major exception, Consolidation Coal, is a subsidiary of Continental Oil). The gas industry, facing more immediate shortages, is more eager, provided they get permission to sell synthetic natural gas at regulated prices high enough to yield a profit.

A number of politicians and public interest groups have opposed subsidies for synthetic fuels as a giveaway to the energy companies. Others are opposed to a wider use of coal in any form because of unresolved environmental and social problems associated with its mining and conversion to clean fuels. On the other hand, many scientists and engineers unconnected with industry have

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called for construction of at least a few synthetic fuel plants, at government expense if necessary, as a form of insurance against the petroleum exporting countries' greed. Still others, impressed with how soon world oil production might begin to decline (10 to 25 years are common estimates) and how long it takes to build up a new industry, have urged rapid and wholesale moves to synthetic fuels.

This debate is reflected in the ambivalence about coal and synthetic fuels in Congress and in the country as a whole. Congress, for example, last year killed a bill to permit federal loan guarantees for the first commercial synthetic fuel plants. Revived this year, the bill was passed by three different committees in the House but gutted in the fourth, and its future is very uncertain. Many observers of the coal research program seem to think that Congress, whose 35 committees and subcommittees dealing with energy leave ERDA little that it can call its own policies, may in fact have set the agency a nearly impossible task in asking it to push the commercialization of new technologies under present conditions.

This ambivalence about coal and about taking decisive measures to relieve this country's dependence on scarce fuels—oil and gas—is not restricted just to Congress. Environmentalists who are opposed to nuclear power plants do not endorse coal-fired plants in their stead. Few industrial companies want to exchange the convenience of oil and gas for the unfamiliar complexities of the equipment necessary to clean up coal or to convert it to a form usable in their existing plants, either. General Motors, for example, which faces a cutoff of the natural gas used in its body plants, has leased drilling equipment and is seeking to develop its own sources of gas rather than buy gasifiers and coal.

Perhaps this reluctance to come to terms with coal explains why White told *Science*, "What we need to get the synthetic fuels program going is a really cold winter," a sentiment echoed by others. That event would most immediately affect the supply of natural gas and draw new atttention to efforts to make synthetic gas, which will be the subject of a second article. But it is a sad comment on the state of the nation's coal research program that its success, so crucial to any eventual hope of energy independence, is so widely acknowledged to be as uncertain as the weather.

—ALLEN L. HAMMOND

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