BY THE COMPTROLLER GENERAL

# Report To The Congress

OF THE UNITED STATES

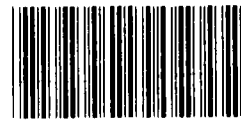
## How To Burn Coal Efficiently And Economically, And Meet Air Pollution Requirements--The Fluidized-Bed Combustion Process

Burning coal more efficiently and economically and meeting air pollution requirements, a goal set by the Energy Department, can be done through fluidized-bed combustion--a process that has been operating successfully in small scale units for years. However, in order to commercialize this technology, its reliability under industrial and utility loads must be demonstrated.

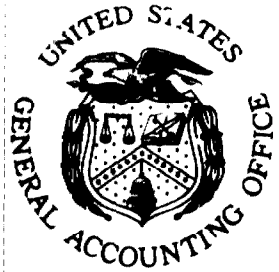
The Department's program has potential but could be improved, specifically by

--entering into an interagency agreement with the Department of Defense to place industrial demonstration plants in Defense's industrial facilities and

--entering into an interagency agreement with the Tennessee Valley Authority for hosting the 200-megawatt utility demonstration plant.







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

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To the President of the Senate and the
Speaker of the House of Representatives

This report discusses the Department of Energy's program to demonstrate fluidized-bed coal combustion and ways the program could be improved. It specifically recommends that the Secretary of Energy: (1) enter into an interagency agreement with the Department of Defense to place industrial demonstration plants in Defense industrial facilities and (2) enter into an interagency agreement with the Tennessee Valley Authority for hosting the 200-megawatt utility demonstration plant. It also discusses the questionable need and utility of a component test and integration unit and suggests options for terminating the contracts and selling or modifying the facility for other uses.

We are sending copies of this report to the Director, Office of Management and Budget; the Secretaries of Energy, Defense, and Air Force; the Director, Tennessee Valley Authority; and interested congressional committees.

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

# HOW TO BURN COAL EFFICIENTLY AND ECONOMICALLY, AND MEET AIR POLLUTION REQUIREMENTS--THE FLUIDIZED-BED COMBUSTION PROCESS

## D I G E S T


The Nation has the potential to reduce its dependence on imported oil through a process known as fluidized-bed combustion--the burning of coal in a mixture of air and limestone, whose end result generates heat and electricity. One of the key factors limiting coal use is the measures that must be taken to burn it in a manner that does not pollute the environment. Fluidized-bed combustion is one of the Department of Energy's research, development, and demonstration programs which has the potential to burn coal more efficiently and economically than conventional coal-fired boilers with pollution control equipment.

Since 1973, the Department of Energy and its predecessor agencies have spent $176 million developing the new process. In addition, the Tennessee Valley Authority (TVA), the State of Ohio, utilities, research organizations, and boiler manufacturers have been funding research for the technology. Other countries, including the United Kingdom, Sweden, and West Germany, have also been interested in fluidized-bed combustion.

Its basic concept is sound and it works. Small scale units have been operating successfully for years. But in order to commercialize the technology, its reliability under industrial and utility loads must be demonstrated. To achieve this demonstration, the Department's demonstration program could be improved through complementary strategies. Specifically:

--Placing industrial-size demonstration units in Department of Defense industrial plants could demonstrate the technology while making needed replacements of old fossil fuel boilers.


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--Entering into an interagency agreement with TVA to host the utility demonstration plant would take advantage of TVA's past research and development efforts and in-house expertise.
--Also, the merits of continuing construction of a research facility called a component test and integration unit should be reevaluated in view of questions raised concerning its usefulness.

PLACE INDUSTRIAL-SIZE DEMONSTRATION UNITS IN DEPARTMENT OF DEFENSE

In 1978 an Energy Department task force reviewed the development status and commercial readiness of fluidized-bed combustion for industrial applications. It recommended that the Department pursue a program of accelerating commercial acceptance of fluidized-bed combustion demonstration plants. These plants would be placed in the most energy intensive industries--paper, chemical, petroleum, and primary metal.

As a complementary strategy, the Department could enter into an interagency agreement with the Department of Defense for the location of fluidized-bed combustion boilers in Government-owned defense industrial plants. Defense has a large number of industrial steam boilers which are in a size range suitable for the Department's proposed commercialization program. Many of these boilers must be replaced in the 1980s.

It is not GAO's intention to discourage the Department from pursuing private industry participation in demonstration projects. However, GAO believes that this approach could also be used to demonstrate the technology. Most of the industry officials GAO contacted felt the demonstrations could be effective regardless of the type of industry selected--even a Government-owned facility--as long as the site used the boiler on a

continuous basis and produced steam for industrial application. Also, assuming successful operation, the Goverment would be getting more for its investment--not only demonstration units, but also replacement units for oil, gas, or outdated coal boilers.

## ALLOW TVA TO HOST THE UTILITY-SIZE DEMONSTRATION PLANT

In addition to industrial applications, the Department has programs underway for larger scale, utility applications of both atmospheric and pressurized fluidized-bed combustion. GAO did not find any substantive problems with the Department's approach to demonstrate pressurized fluidized-bed combustion--presently in the pilot plant design phase. However, the Department's efforts to construct an atmospheric fluidized-bed combustion utility demonstration plant could be improved through the complementary strategy of entering into an agreement with TVA for a demonstration plant.

The Department's original plans specified a solicitation proposal for the demonstration plant to be released in October 1977, calling for a 50-50 cost sharing with a private utility. However, the proposal has never been released.

On the other hand, TVA, through its skilled and experienced personnel, has past and ongoing research activities to vigorously pursue fluidized-bed combustion research and development. TVA's efforts are leading to the near-term establishment of a commercially viable utility demonstration facility. As the Nation's largest utility, it is willing and able to assume the leadership role in demonstrating utility applications of fluidized-bed technology.

In regard to atmospheric fluidized-bed combustion, TVA is now constructing a 20-megawatt pilot plant which is scheduled for completion in January

1982. TVA has also completed preliminary design and environmental work and has awarded contracts for final design of the 200-megawatt demonstration plant. The demonstration plant's estimated start-up date is 1986. TVA and the Department already have a memorandum of understanding setting forth the basic principles and guidelines for entering into interagency agreements. Thus, it would appear that an interagency agreement could be easily negotiated.

## QUESTIONABLE NEED FOR COMPONENT TEST AND INTEGRATION UNIT

GAO agrees with the concept of flexible test facilities to minimize risk in developing new technologies. However, they should be constructed at the early stages of development of a technology and not in the later stages as with the fluidized-bed combustion test unit. GAO has raised several key issues concerning the usefulness of the planned $49.8-million, 6-megawatt atmospheric test unit: (1) several other research facilities exist for testing fluidized-bed combustion; (2) the data received may not be generated in time to affect designs of the utility projects; and (3) the boiler manufacturers, whose participation is essential, may not use the unit.

## RECOMMENDATIONS

The Secretary of Energy should make every effort to demonstrate the commercial feasibility of fluidized-bed combustion as a means of increasing coal use in the country. Specifically, we recommend that the Secretary:

--Enter into an interagency agreement with the Department of Defense to place industrial demonstration plants in Defense's industrial facilities.

--Enter into an interagency agreement with the Tennessee Valley Authority for

hosting the 200-megawatt utility demonstration plant.

In addition, in view of the questions raised concerning the usefulness of the atmospheric component test and integration unit, GAO recommends that the Secretary:

--Reevaluate the costs and benefits of continuing its plans for the test facility, including options for terminating the contracts and selling or modifying the facility for other uses.

## AGENCY COMMENTS

Copies of the draft report were sent to the Department of Energy, the Tennessee Valley Authority, the Department of Defense, and the Air Force. TVA, the Department of Defense, and the Air Force generally agreed with the report and provided only informal comments. The Department of Energy provided formal comments. (See app. I.)

While the Department of Energy agreed that it should accelerate its fluidized-bed combustion program in order to demonstrate the technology's reliability as soon as possible, the Department questioned whether our recommendations would achieve this goal. Specifically the Department questions the merits of placing industrial-size demonstration units in Defense facilities and of selecting TVA as host for the utility-size demonstration plant. In addition, the Department continues to believe there is a need for the test facility being built in Morgantown, West Virginia, and also raised some environmental questions regarding the technology.

GAO continues to believe that placing demonstration units in Defense and TVA will improve the Department's program and that the merits of the test facility be reevaluated. Although GAO believes the environmental issues raised by the Department need additional attention, GAO believes that they have been overstated.

# Contents

## ABBREVIATIONS

| | |
|---|---|
| AEP | American Electric Power |
| AFBC | atmospheric fluidized-bed combustion |
| Btu | British thermal unit |
| B&W | Babcock & Wilcox |
| CTIU | Component Test and Integration Unit |
| DOE | Department of Energy |
| EPA | Environmental Protection Agency |
| ERDA | Energy Research and Development Administration |
| EPRI | Electric Power Research Institute |

## ABBREVIATIONS

| | |
|---|---|
| ESECA | Energy Supply and Environmental Coordination Act |
| GAO | General Accounting Office |
| OCR | Office of Coal Research |

# CHAPTER 1

## PERSPECTIVE

As a means of reducing dependence on imported oil, the Federal Government has attempted to increase the Nation's use of coal mainly through regulatory procedures and research and development. Despite these actions, coal's usage has not significantly expanded. Key factors limiting coal's use are the measures that must be taken to burn it so that it does not pollute the environment. Fluidized-bed combustion is one of the Department of Energy's (DOE's) research, development, and demonstration programs slated for burning coal more efficiently and economically than conventional coal-fired boilers with pollution control equipment.

## FEDERAL EFFORTS

Only a moderate increase in coal use has resulted despite several regulatory actions taken by the Government. The Energy Supply and Environmental Coordination Act (ESECA) of 1974 (Public Law 93-319), for example, allowed the Government to order existing powerplants and other major fuel-burning installations 1/ which were properly equipped to burn coal to discontinue burning oil or gas, and companies to install coal-firing equipment in new large facilities.

The ESECA program had very little impact on increasing the use of coal, largely because the Government had to first go through the extremely burdensome and time-consuming task of identifying installations subject to its provisions and then demonstrating in each case that it was both economically feasible and environmentally acceptable for these installations to burn coal.

On November 9, 1978, the President signed, as part of the National Energy Act of 1978, the Powerplant and Industrial Fuel Use Act (Public Law 95-620), which, in a large part, replaces ESECA. The new act relieves some of the administrative problems experienced under ESECA by putting the burden of reporting and requesting exemptions on the private sector.

Laws requiring mandatory coal use were passed because it became obvious that coal was not the preferred fuel of energy users. Coal is dirty; it is bulky; it is seldom

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1/Boilers using over 100 million British thermal units (Btu's) per hour.

found where needed; and it varies widely in quality, in terms of chemical impurities, heat content, and combustion characteristics. Perhaps the problem most affecting coal's use is that when coal is burned, it pollutes the air; thus, measures must be taken to meet National and State air pollution requirements.

## AIR POLLUTION REQUIREMENTS

The Clean Air Act, as amended, is administered by the U.S. Environmental Protection Agency (EPA) and is the fundamental law governing air quality standards. This act and the other Federal, State, and local air quality standards form a myriad of air pollution regulations. The standards are based not only on shared authority, but on overlapping strategies of control--one based on compliance standards for individual sources, the other based on area management of ambient air quality.

The act's sulfur dioxide standard, which is the most controversial, is based upon the effectiveness of pollution control devices. The new standards, announced in final in the Federal Register in June 1979, require a 90-percent reduction in sulfur dioxide emissions when high-sulfur solid fuels are burned, and a 70-percent reduction when low-sulfur solid fuels are burned. EPA's regulations would require some equivalent pollution control device on all new coal-burning electric powerplants. As a result, DOE has stated that the standards will cause an increase in the use of imported oil and a decrease in the use of coal. The Deputy Secretary of Energy, in a July 6, 1978, letter to EPA's Administrator, estimated that the present value cost through 1990 to electricity consumers for pollution control equipment to meet an 85-percent reduction requirement will be between $62 and $73 billion--the former estimate, if scrubber systems are 100-percent available; the latter, if they are 90-percent available.

## ARE SCRUBBERS THE ANSWER?

EPA 1/ believes that flue gas desulfurization equipment (scrubbers) represent the best available control technology

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1/EPA is the forerunner of scrubber technology in the Federal Government. However, lead responsibility for advanced environmental control technology was transferred to DOE in fiscal year 1979. DOE's 1980 budget request for this program is $25 million.

for removing sulfur dioxide from the flue gases of coal-fired boilers. A scrubber is a unit added to a boiler which reduces sulfur emissions during combustion. In a scrubber, smoke rises through a spray of water mixed with limestone that chemically "captures" the sulfur compounds. As the percentage of sulfur to be removed becomes higher, additional scrubbers are needed.

U.S. industry takes a decidedly different view of scrubbers, stressing that scrubbers are still a developing technology and, despite the best efforts and ability of scrubber manufacturers, may not live up to design expectations, particularly where high sulfur coal is used.

In addition to questioning the reliability of scrubbers, American utilities have been against their use because scrubbers increase the cost 1/ of generating electric power. A portion of this increased cost is associated with additional personnel cost. The Tennessee Valley Authority (TVA) estimates that 50 additional trained personnel are needed to operate and maintain a scrubber. And scrubbers consume as much as 5 percent of the power generated, so additional generating capacity will have to be installed to compensate for the loss.

Another problem with scrubbers is that they create sludge; utilities believe the most difficult problem associated with scrubbers is sludge disposal. Not only is the volume enormous, 2/ but the sludge must be (1) disposed of in a pond lined to prevent the sludge from seeping into the groundwater or (2) chemically treated to make it suitable for landfill. The scale of the problem is illustrated by the disposal plans for a power station in Pennsylvania, where a valley is being dammed and will, over the next 25 years, be filled to a depth of 400 feet with sludge pumped through a special 7-mile long pipeline. According to our September 1977 report to the Congress entitled "U.S. Coal Development--Promises, Uncertainties" (EMD-77-43), annual sludge disposal costs, using 1975 dollars, will be in the range of $22 billion to $34 billion by the year 2000.

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1/A 1975 analysis performed for EPA by Pedco Environmental Specialists, Inc., stated that scrubber costs range from $33,000 to $205,000 per megawatt of capacity.

2/Eight or nine cubic feet per ton of coal burned or about 80,000 cubic feet per day for a 1,000-megawatt powerplant burning high-sulfur coal.

## FLUIDIZED-BED COMBUSTION BOILERS OFFER AN ALTERNATIVE TO SCRUBBERS

An alternative to the conventional methods of burning coal is fluidized-bed combustion, which can potentially burn all types of coal in an economic, efficient, and environmentally acceptable manner. In a fluidized-bed system, sized and crushed coal and limestone (or dolomite) are mixed in a heated chamber. Air is blown into the chamber to mix the coal and limestone in such a manner that the limestone absorbs the sulfur dioxide that is released from the coal. Hot water or steam is produced and may be used to heat buildings, generate process steam for industrial purposes, or generate electricity.

Two types of fluidized-bed boilers are being developed: (1) atmospheric boilers and (2) pressurized boilers. The atmospheric fluidized-bed boiler, which is more advanced, operates at normal pressure to produce steam. This technology has both utility and industrial applications. The pressurized fluidized-bed boiler, having more potential efficiency because it is adaptable to combined-cycle systems, 1/ operates at 7 to 16 times normal pressure to produce hot pressurized combustion gases necessary for gas turbines. This technology is currently being developed solely for utility applications.

The advantages of fluidized-bed combustion over conventional coal combustion with scrubbers are:

--Higher potential utilization of boiler waste product. A dry solid waste results from the fluidized-bed combustion process, which has more potential for utilization than the sludge produced by scrubbers. Studies are underway to test the dry solid waste's use as a soil conditioner, building material, and soil stabilizer for road beds. If these uses do not prove successful, the easier-to-transport dry waste could still be used as a stable landfill material.

--Ability to use fuels of all grades. This is another important advantage of fluidized-bed combustion. While a conventional coal-fired boiler is designed to burn a specific type of coal, a fluidized-bed has

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1/Two sequential power conversion systems operating at different temperatures, where the exhaust gases from the primary turbine are passed through to either another turbine or another boiler to produce steam.

the ability to burn coal of all types without major modifications to the boiler. This advantage provides users with flexibility when transportation and other problems arise and to negotiate for the least expensive coal. It also has the ability to burn low quality coal which is unuseable in conventional boilers.

--Low nitric oxide emissions due to low combustion temperatures. Because of the relatively low combustion temperatures (1,500 degrees to 1,700 degrees Fahrenheit) of fluidized-bed boilers compared to conventional coal combustion temperatures (2,500 degrees to 3,000 degrees Fahrenheit), much less nitric oxides, which are also regulated by EPA, are emitted. The low temperatures also aid in fuel flexibility because the temperature inside a fluidized-bed boiler is below the melting point of coal ash. This is important because, when high-ash coal is burned in a conventional boiler, the ash melts and causes plugging and scaling in the boiler. High-ash coal can be burned in a fluidized-bed boiler without causing these problems.

--Less water used in the process. Since fluidized-bed systems do not use water in controlling sulfur, whereas scrubbers do, water is saved. In addition, while bottom ash from a conventional plant requires water for cooling, atmospheric fluidized-bed spent solids are cooled by air. This is of particular importance in drier parts of the country.

--No additional operators needed as with scrubbers. No additional operators are needed as with a scrubber system. This cuts down the operating cost of a fluidized-bed system.

Because there are no commercial fluidized-bed combustion units operating, the true economics of fluidized-bed combustion are not well defined. But DOE estimates that when it is commercial, the capital and operating costs of fluidized-bed combustion will be the same or even less than conventional coal-fired boilers with scrubbers.

With all the apparent advantages of fluidized-bed systems, one would wonder why they are not widely used for coal combustion. Industry representatives' main response is that fluidized-bed boilers are considered a high risk because they are unproven for industrial loads. They told us

that before purchasing one, their reliability and cost effectiveness for industrial loads at industrial sites must be demonstrated. Similar views are expressed by the utilities.

Hence, despite the distinct advantages of fluidized-bed combustion, some uncertainties have to be resolved. These involve aspects such as developing an efficient coal feed system and determining, for the pressurized system, how to clean the hot gases before they go into the gas turbine. For the feed system, it is necessary to establish (1) an acceptable range of coal particle sizes, (2) the best way to introduce them into the bed, and (3) the optimum number of feed points required for a given bed area. Concerning the hot gas cleanup problem, without a system to filter particulates from the gases, the turbine blades will be damaged.

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The following chapters describe

--the Government's and others' involvement in the development of fluidized-bed combustion,

--DOE's strategy for promoting the development and commercialization of the technology, and

--ways which we believe this strategy could be improved in order to accelerate commercialization.

## CHAPTER 2

## EXPERIENCE WITH FLUIDIZED-BED TECHNOLOGY

Many participants, including the public and private sectors in both the United States and Europe, have been involved with fluidized-bed technology for a long time. The concept of a fluidized-bed was first introduced in Germany in the 1920s when it was found that the mixing of materials within a fluidized-bed would promote chemical reactions. By the early 1940s, fluidized-beds for refining crude oil were commercially available and other applications, such as for metallurgical heat treatment, followed. In such applications, however, the heat produced within the bed was eventually discharged as a by-product. The idea of burning coal in a fluidized-bed boiler to supply heat or generate steam is relatively new.

### DOE'S AND PREDECESSORS' INVOLVEMENT

The U.S. Government first became involved in fluidized-bed coal combustion in 1965 when the Department of the Interior's Office of Coal Research (OCR) 1/ sponsored construction of three fluidized-bed test units. In 1972 OCR provided all the financing for a 30-megawatt atmospheric fluidized-bed pilot powerplant at Rivesville, West Virginia. This powerplant is currently in operation, and although it has not had major technological problems, it has been plagued by problems such as the coal strike of 1978 and a fire at the installation.

From the mid-1960s through the mid-1970s, the Government did not give coal combustion technologies, including fluidized-bed, priority in comparison to other energy research activities, since oil and natural gas were still readily available and relatively inexpensive when compared to coal. After the oil embargo and fourfold oil price increase of 1973, however, the Government changed its priorities, which in turn affected the development of fluidized-bed technology. By late 1975, the Energy Research and Development Administration (ERDA), a predecessor of DOE, was inviting organizations to join in research and development of direct coal combustion technologies, particularly

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1/These functions were transferred to the Energy Research and Development Administration on January 19, 1975, and from there to DOE on October 1, 1977.

fluidized-bed combustion. Since 1973, the Government has spent $176 million developing fluidized-bed combustion.

Federal fluidized-bed efforts have included various stages of design and construction of component test and integration units, pilot plants, and demonstration units. The definitions for these terms follow.

--Component test and integration unit: Used by DOE to address hardware and process problems, as well as optimize the system on a scale which is large enough to utilize commercial-scale equipment and operating conditions. This type of unit is flexible since it can be used to test components for both pilot and demonstration plants.

--Pilot plant: Used by DOE to determine whether a process works with commercial-type components, acquire engineering data needed to design a larger demonstration plant, and estimate the economics of a commercial-size plant.

--Demonstration plant: Used by DOE to demonstrate and validate the economic, environmental, and productive capacity of a near-commercial plant using commercial-size components and to minimize risks in accelerating industrial application.

As a result of the increased emphasis on coal, ERDA awarded five contracts for industrial atmospheric fluidized-bed demonstration units in 1976 since ERDA believed these units represented the best near-term potential for commercialization. These units are discussed in more detail on page 13.

ERDA also became interested in developing large pressurized fluidized-bed combustors to feed into gas turbines 1/ for use in electrical power generation. Consequently, in 1976 it contracted to design and build a coal-fired combined-cycle pilot plant using a pressurized fluidized-bed boiler. In the same year, ERDA also started preliminary design work on a utility-size (200-megawatt) atmospheric fluidized-bed combustion demonstration plant. Conceptual design contracts were completed in fiscal year 1978 and analyses were conducted to determine the effects of EPA's revisions to the sulfur removal requirements. However, according to DOE's March

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1/These turbines do not use natural gas but, rather, the gases created and fed to them by the combustors.

1979, Fossil Energy Program Summary Document, preprocurement activity has been suspended until additional engineering data is gathered.

DOE also plans to build an atmospheric component test and integration unit designed to study problems encountered with atmospheric fluidized-bed combustion. (See ch. 5.)

In addition to DOE, other groups including TVA, the State of Ohio, utilities, research organizations, and boiler manufacturers have been funding research for fluidized-bed combustion. Other countries, including the United Kingdom, Sweden, and West Germany, have also been interested in fluidized-bed combustion. Details of the efforts of those most heavily involved in the technology follow.

## TENNESSEE VALLEY AUTHORITY

TVA is the Nation's largest utility, with over 160 municipal and cooperative distributors of its power and nearly 150 direct industrial customers. TVA produces more electricity and burns more coal (40 million tons per year) than any other utility in the Nation. It has expertise and experience in dealing with research and development activities and in implementing new energy-related technologies. For example, it has been involved in the development of scrubber technology and has closely followed the development of fluidized-bed combustion.

In September 1976, TVA's Board of Directors approved a program plan for the design and construction of an atmospheric fluidized-bed combustion demonstration powerplant. An initial $4-million commitment was made for preliminary design, siting, and cost analysis work. Subsequently, in July 1977, TVA entered into an interagency agreement with ERDA whereby ERDA was to provide an amount not to exceed $1.25 million to this program for three steam boiler designs. In August and September 1979, TVA awarded contracts valued at $39.5 million for fluidized-bed combustion--$34.7 million to construct a 20-megawatt pilot plant, and $4.8 million for final design of the 200-megawatt demonstration plant.

In February 1977, TVA established a consortium with 11 other utilities to exchange information on fluidized-bed combustion. This consortium, whose efforts have been endorsed by the Electric Power Research Institute, has had four meetings.

## STATE OF OHIO

Although other States, including Illinois and New York, have expressed an interest in fluidized-bed combustion, Ohio has assumed the lead role among the States in this technology.

Ohio is interested in promoting the use of high sulfur coal, since (1) most of the coal produced in the State is more than 3 percent sulfur and (2) virtually none of Ohio's coal can be burned in a conventional boiler without a scrubber and be in compliance with EPA's recommended standards for sulfur dioxide. The State presently imports nearly 50 percent of its coal, and State officials fear the imposition of standards on sulfur dioxide emissions will cause utilities and industry to import more low-sulfur coal.

Among its energy programs, Ohio has awarded a high priority to the introduction of fluidized-bed technology. Three engineering design studies for fluidized-bed combustion boiler installations have been funded, and the State intends to support construction of two of the designs: a retrofit boiler (generating 60,000 pounds of steam per hour) 1/ at a psychiatric hospital and a new 100,000 pounds of steam per hour boiler at a penitentiary. The third study was for a utility powerplant (generating 355,000 pounds of steam per hour) which would require private funding. State officials had also hoped to sponsor a demonstration in an industrial plant; however, the Ohio companies contacted were not willing to participate. These companies were reluctant to take the financial risks associated with a research and development project, especially in view of uncertainty surrounding the legislation which eventually culminated in the National Energy Act (Public Laws 95-617 to 95-621). There was also a lack of interest in using coal in their plants because of ready access to oil and gas.

In order to finance its fluidized-bed projects, Ohio proposed to have the State's electric utilities collect a coal use tax from their customers. The utilities, however, have balked at adding the tax to their already unpopularly high rates, and the implementation of the projects has been delayed. The State did have sufficient funding to start construction on the hospital project in November 1978. The earliest operational start-up for the unit is projected for November 1979.

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1/For comparability purposes, this would approximate the size of a 6-megawatt powerplant.

## AMERICAN ELECTRIC POWER

American Electric Power (AEP) is one of the largest investor-owned electric companies in the world. In 1977 about 94 percent of AEP's power production was from coal. AEP is committed to the use of coal as an energy source but does not favor the use of scrubbers because it claims they lower the efficiency of powerplants.

In looking for alternatives to scrubbers, AEP assessed both atmospheric and pressurized fluidized-bed combustion. Since pressurized fluidized-bed combustion offers higher efficiencies, AEP made a commitment to develop this technology. Although AEP believes that pressurized fluidized-bed combustion can be commercialized possibly even before atmospheric fluidized-bed combustion, individuals we contacted believe pressurized fluidized-bed combustion will not be commercial until sometime after the early 1990 time frame projected for commercialization of the atmospheric process.

AEP has plans to design and build a 170-megawatt combined-cycle powerplant which would use a pressurized fluidized-bed combustor. A feasibility study for the plant has been completed. The demonstration facility is planned to be located at an AEP generating plant in Brilliant, Ohio. If the demonstration plant is successful, AEP stated that it will design and construct a commercial-size plant. AEP hopes to have its demonstration plant completed by late 1983. To finance this effort, AEP plans to approach DOE, the Electric Power Research Institute, and other utilities for funding assistance. AEP stated it cannot handle such a large financial committment alone.

## ELECTRIC POWER RESEARCH INSTITUTE

The Electric Power Research Institute was founded in 1972 by the Nation's electric utilities to develop and manage a technology program for improving electric power production, distribution, and utilization. It has funded research into utility applications of both atmospheric and pressurized fluidized-bed combustion including design, construction, and operation of several test facilities. One test facility, funded jointly with a major boiler manufacturer, is now performing testing for the design of a utility-size atmospheric fluidized-bed combustion powerplant.

## UNITED KINGDOM

In the early 1960s, the United Kingdom's National Coal Board, British Coal Utilization Research Association, and

Central Electricity Generating Board began collaborating to investigate the potential of new methods of using coal in power generation, including fluidized-bed combustion. By 1969, several small experimental test units were in operation at Stoke Orchard and Leatherhead, Great Britain. The test results were used by a British boiler manufacturer which successfully converted a conventional boiler to an atmospheric fluidized-bed combustion boiler (40,000 pounds of steam per hour) at Renfrew, Scotland. U.S. Government contractors have used these units to obtain test data. In addition, at Grimethorpe, England, a flexible 80-megawatt pressurized fluidized-bed combustion test facility is being constructed under the sponsorship of the International Energy Agency. Funding is being provided equally by the United States, the United Kingdom, and West Germany.

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In summary, a great deal of interest has been expressed and a lot of work has been done in fluidized-bed coal combustion by the Government and private industry, both in the United States and abroad. The concept of fluidized-bed combustion is sound and it has the potential to burn coal in an economic, efficient, and environmentally acceptable manner. However, in order to commercialize the technology, its reliability under industrial and utility loads must be demonstrated.

# CHAPTER 3

# A COMPLEMENTARY STRATEGY TO CURRENT GOVERNMENT EFFORTS TO PROMOTE FLUIDIZED-BED APPLICATIONS OF INDUSTRIAL NEEDS

DOE's efforts to promote fluidized-bed combustion applications in the industrial sector only involve atmospheric fluidized-bed combustion, since pressurized fluidized-bed combustion presently has primarily only utility applications. DOE has in progress five projects to demonstrate industrial applications of atmospheric fluidized-bed combustion technology. In 1978 a DOE commercialization task force on industrial atmospheric fluidized-bed combustion recommended that the Department accelerate commercial acceptance of fluidized-bed combustion by also sharing in the cost of four commercial demonstrations in the four most energy-intensive industries.

This chapter will discuss, in detail, the five current fluidized-bed combustion projects and the DOE task force recommendation. It will also discuss a complementary strategy for commercializing industrial fluidized-bed combustion, that of placing boilers in Department of Defense installations.

## CURRENT DEMONSTRATION PROJECTS

DOE's current projects for industrial applications of atmospheric fluidized-bed technology include three boilers for steam generation, a boiler to heat air, and a distillation system to heat crude oil for use in a refinery. Only two of the steam generation boilers are conventional fluidized-bed systems. The third employs an advanced concept whereby a bed containing sand is added to the conventional system. This addition will allow for a higher bed velocity, and consequently, a potentially higher combustion efficiency.

Both DOE and industry officials generally agree that only conventional atmospheric fluidized-bed boilers are ready for near-term commercialization. The two DOE projects that fall into this category are

--a 100,000 pounds of steam per hour boiler at Georgetown University, Washington, D.C., and

--a 50,000 pounds of steam per hour boiler at Great Lakes Naval Base, Illinois.

Construction of the Georgetown boiler plant has been completed. Its systems are currently being tested and operations are anticipated for the 1979-80 heating season. The Great Lakes project is in the construction phase at this time, with operations scheduled to start in mid-1980. The other projects were still in subscale testing and demonstration plant design, with start-up dates scheduled for late 1980.

Probably the most significant shortcoming of the current demonstration program is the absence of a steam boiler at a representative industrial site. DOE did receive responses from the chemical, automotive, and food-processing industries. However, concerns regarding reliability and the financial investment of each of the participants (DOE, the boiler manufacturers, headquarters personnel of the user companies, and plant management) could not be resolved. For example, a DOE official stated that plant management generally has little compassion for research and development. Plant managers are judged primarily on the level of a plant's production and ultimately profit--not on how they assist research and development.

This is not to say that the current program is without merit or that the projects will not contribute to the acceptance of fluidized-bed combustion. Any demonstration of reliable performance is a step in the direction of commercial acceptance. The experience gained by the boiler manufacturers is important, since their willingness to guarantee the operational performance of fluidized-bed combustion boilers is one of the keys to commercial acceptance. The current projects may also help resolve some of the remaining technical reservations about fluidized-bed combustion. Using a different type of feeding system at the Georgetown plant, for example, may eliminate the clogging problem in the current feed system.

## PROPOSED COMMERCIALIZATION PROGRAM

In 1978 a DOE task force reviewed the development status and commercial readiness of fluidized-bed combustion for industrial applications. It solicited the views of a variety of industries, and contracted for "case studies" with companies in each of the four most energy intensive industries--paper, chemical, petroleum, and primary metal. The task force reported that fluidized-bed combustion technology had been proven at a small scale but its operational reliability at a commercial scale remained to be demonstrated. It recommended that DOE accelerate commercial acceptance of fluidized-bed combustion by sharing in the cost of four

commercial-size steam plants to be placed in the four most energy-intensive industries.

The task force concluded that demonstrations in energy-intensive industries were needed to establish the operational reliability, environmental performance, and actual cost basis of fluidized-bed combustion units. DOE officials involved in the preparation and review of the task force report told us that industrial officials, especially in energy-intensive sectors, view their needs as unique and want to see direct application of the technology to their particular industrial processes in order to judge its suitability.

The task force chairman stated that the total cost for four commercial-size boilers would be $50 million; however, only $20 million would be Federal funds, with the remaining $30 million being provided by industry.

Based on our interviews with industry and boiler manufacturer officials, we agree with the task force conclusion that general acceptance of fluidized-bed combustion is dependent on fluidized-bed boilers operating on a continuous basis in an industrial setting. Although the task force felt it imperative that these boilers be placed in each of the four most energy-intensive industries, most of the industry officials we contacted felt the demonstrations would be effective regardless of the type of industry selected--even in a Government-owned facility--as long as the site used the boiler on a continuous basis and produced steam for industrial application.

## FLUIDIZED-BED COMBUSTION DEMONSTRATIONS COULD BE LOCATED AT DEFENSE INDUSTRIAL PLANTS

In light of (1) these discussions with private industry and (2) unsuccessful attempts by DOE and the State of Ohio in the past to reach agreement with private industry (see pp. 10 and 14), we believe that DOE should pursue a complementary strategy to its proposed commercialization program by entering into an interagency agreement with the Department of Defense for the location of fluidized-bed combustion boilers in Government-owned Defense industrial plants.

This is not to say, however, that efforts to place fluidized-bed demonstrations in the private sector should be discontinued. Our proposed strategy would complement DOE's current strategy.

Defense owns a large number of industrial facilities throughout the country. Many of these plants are in a size range suitable for DOE's proposed commercialization program since they use large amounts of steam and process heat for industrial applications such as explosives manufacturing, aircraft assembly, aluminum casting, chemical plating, and jet engine manufacturing.

It appears there will be a growing need for new boilers at Defense installations in the 1980s. Many defense industrial plants were built in the early 1940s and are still using some of the original steam generating equipment. An Air Force official estimated that 60 percent of the 100 major Air Force installations utilize boilers more than 25 years old. Navy officials told us that based on surveys to determine the expected life of their current onshore boilers of 50 million Btu's per hour or greater, six to eight should be replaced each year in the 1980s. However, funding constraints will probably hold these replacements to three or less a year.

We found considerable interest in fluidized-bed combustion among engineering personnel in the military departments. Military command personnel, however, have concerns, similar to those of industry, about reliability and the risks of pioneering a new technology in a support area. As a result, they will probably purchase conventional coal-fired equipment with its demonstrated reliability, thus delaying the introduction of fluidized-bed combustion to the military. Defense officials told us, however, that DOE sponsorship of and participation in a fluidized-bed project could accelerate this introduction. It would not only provide funding assistance, but also additional justification for the engineering personnel in their efforts to sell the projects. These personnel could argue that these projects are energy research and development efforts emanating from the national energy plan and in consonance with the Defense objective of increasing coal use. 1/

Based on the criteria that general acceptance of fluidized-bed combustion is dependent on fluidized-bed boilers operating on a continuous basis in an industrial setting, we selected the Air Force to determine if certain

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1/A Defense memorandum of March 1, 1978, established a goal to have at least 10 percent of each Defense installation's energy supplied from solid fuels by 1985. This policy includes converting gas- and oil-fired systems to coal firing.

Defense industrial sites could be incorporated into DOE's proposed commercialization program. We reviewed in detail two Air Force facilities; one Government owned and operated, and one Government owned/contractor operated.

Government owned and operated facility

In June 1978, Battelle Columbus Laboratories, under contract to the Air Force, issued a report on the desirability and feasibility of new alternative energy systems for Air Force Logistics Command installations. The Air Force Logistics Command has five large industrial complexes called Air Logistics Centers which are responsible for maintenance and repair of Air Force weapons systems. The Command uses natural gas as the primary source of energy and fuel oil as the backup source.

Concerning oil and gas availability, the study states that:

> "Shortages of natural gas and restrictions on its use, coupled with problems in expanding utilization of coal without significant deterioration in air quality, make it mandatory for the AFLC [Air Force Logistics Command] to continue and intensify its efforts to conserve energy and to reduce its reliance on natural gas and fuel oil."

The study reached the following conclusion and recommendation for steam generation at these industrial sites:

> "A coal-fired steam-generation system with multi-fuel firing capability is recommended at the time it becomes mandatory to discontinue use of present oil/gas fired systems. It would be economically advantageous to continue oil-firing of present systems for the next several years, and it might also be technically preferable as it would give additional time for demonstration of fluidized-bed combustion technology." [Emphasis added.]

The Air Force Logistics Command selected the Oklahoma City Air Logistics Center, with buildings occupying about 11.6 million square feet and 19,640 employees, for detailed study by Battelle. The study included a cost comparison between conventional coal-fired boilers and an atmospheric fluidized-bed combustion boiler. Battelle developed this comparison by utilizing information in the literature for industrial boiler plants and components and its experience

from various similar studies. The results of the cost comparison for a life cycle of 25 years were as follows:

Table 1

Life cycle cost comparison of

600,000 pounds of steam per hour

coal-fired energy systems options

(costs in 1977 dollars)

| System option | Sulfur content of coal | 25-year life cycle cost (millions) |
|---|---|---|
| Conventional coal-fired boiler | Low | 116.3 |
| Conventional coal-fired boiler plus scrubber | High | 133.7 |
| Fluidized-bed combustion | Low | 119.7 |
| Fluidized-bed combustion with limestone | High | 124.8 |

There is relatively little difference for 25-year life cycle costs. Fluidized-bed combustion is only 3 percent higher than conventional coal-firing without a scrubber. Where control of sulfur emissions is required, the fluidized-bed combustion system is about 7 percent less than a conventional coal-fired boiler with scrubber.

Based on its study, Battelle recommended that

--low sulfur coal be used at the present time as the fuel;

--scrubbers not be installed initially but the boilers be designed with a scrubber provision;

--three conventional coal-fired boilers be installed--two at about 200,000 pounds of steam per hour, and one at 100,000 pounds of steam per hour; and

--one fluidized-bed combustion boiler of 100,000 pounds of steam per hour be installed.

Battelle stated that its recommendations could well change, depending on technological advancements, new air pollution regulations, and new fuel-cost patterns.

The fluidized-bed boiler was recommended so that the performance and reliability of this technology could be demonstrated. Battelle also said that if the choice of firing method is delayed for a few years, fluidized-bed combustion could be the preferred firing method for all the boilers.

Based on this study and our discussions with boiler manfacturers and industry representatives, we believe a fluidized-bed combustion unit operating continuously under an industrial load at an Air Logistics Center would assist industry in determining if fluidized-bed boilers are reliable and cost effective. Although industry would not be directly involved, the results of the demonstration would be readily available.

Government-owned/contractor-operated plant

The Air Force has a number of industrial plants which are Government owned and contractor operated. These plants manufacture a variety of products such as jet engines, rocket cases, airplanes, and a space shuttle orbitor.

We did not survey all Government-owned/contractor-operated facilities to determine the best location to install a fluidized-bed demonstration boiler. Instead, we identified one possible location, Air Force Plant No. 6 at Marietta, Georgia, operated by the Lockheed-Georgia Company. The plant provides spare aircraft parts, aerospace ground equipment, and C-130 transport airplanes and has a work force of about 122 Government and 9,943 contractor employees. The total industrial floor space at the plant is 4.5 million square feet.

Gas and oil presently generate the plant's steam for heating and production processes. The plant has four 100,000 pounds of steam per hour boilers in operation, which cannot be converted to coal. These boilers are 34 years old and approaching the end of their useful life.

Lockheed-Georgia investigated the availability, merits, and advantages of fuels other than oil or gas. It concluded that the most abundant and readily available fuel in the

foreseeable future will be bituminous coal. The solution it recommended in April 1977 to the Air Force was replacing the present steam generating plant with a pulverized coal plant of the same capacity at an estimated cost of about $2.2 million in fiscal year 1980 and $19.6 million in fiscal year 1981. In order to insure an adequate supply of steam during construction of the new plant, Lockheed-Georgia also proposed that two existing inactive 50,000 pounds of steam per hour coal-fired boilers be put back in service during fiscal year 1980, at a cost of $1.3 million.

There are a number of reasons why we feel this type of facility would be a good demonstration site for a fluidized-bed combustion boiler.

--The plant's manufacturing processes require a constant supply of steam.

--The size of the boilers required are in the large industrial category.

--The existing boilers are old enough to justify replacement.

--The plant is operated by a private contractor, providing first-hand knowledge of operation from a non-Government source.

--Assuming successful demonstration, the total cost to the Government would be less than if it had to purchase both a demonstration and a replacement boiler.

--Potential problems involving private industry's past reluctance to install fluidized-bed boilers would be avoided.

An added advantage of this particular site is that backup boilers are available which could provide steam during construction and shake-down of the fluidized-bed demonstration boiler.

This plant does not fall into one of the four major energy-intensive industrial sectors identified by DOE. However, as stated previously, based on our interviews with industry and boiler manufacturer representatives, the more important consideration is that fluidized-bed demonstration boilers operate at industrial loads on a continuous basis.

## CONCLUSIONS

We believe DOE should make every effort to demonstrate the commercial feasibility of industrial applications of fluidized-bed combustion technology as a means of increasing coal use in the country. DOE should continue to pursue private industry participation in fluidized-bed combustion demonstration projects. However, (1) since the type of industry and ownership (private or Government) do not appear to be the key issues and (2) efforts in the past to reach agreement with the private sector on a fluidized-bed demonstration project have been unsuccessful, we believe that the Department should pursue, as a complementary strategy, an interagency agreement with the Department of Defense for the location of fluidized-bed combustion boilers in Government-owned Defense industrial plants. Defense, with the Air Force in particular, is enthusiastic about participating in demonstrating the technology. Also, assuming successful operation, the demonstration boilers could serve as replacement boilers for oil, gas, or outdated coal-fired boilers.

## RECOMMENDATION

We recommend that the Secretary of Energy enter into an interagency agreement with the Department of Defense to place industrial demonstration plants in Defense industrial facilities.

# CHAPTER 4

# A MEANS FOR THE GOVERNMENT TO PROMOTE FLUIDIZED-BED COMBUSTION FOR UTILITY APPLICATIONS

In addition to industrial applications, DOE has many projects underway for utility applications of both atmospheric and pressurized fluidized-bed combustion. Our review did not disclose any substantive problems with DOE's approach in its pressurized program. Concerning atmospheric fluidized-bed combustion, however, we believe that the proposed utility demonstration plant is worthwhile and should be pursued expeditiously. This chapter discusses (1) why a utility-size, atmospheric fluidized-bed demonstration plant is needed; (2) why DOE delayed requesting funds for the plant; and (3) why we believe DOE should select the Tennessee Valley Authority as host for the demonstration plant.

## NEED FOR DEMONSTRATION PLANT

Utilities, like industry, also prefer to minimize risks of introducing new technology. Hence, a demonstration step is necessary to convince utilities of the attractiveness of fluidized-bed combustion as an alternative to conventional coal-fired plants with scrubbers. Utility companies will accept the technology only if they are convinced that fluidized-bed combustion powerplants will (1) operate effectively and reliably in an interconnected electric power system; (2) meet all Federal, State, and local environmental regulations; and (3) require less capital and operating costs compared to conventional coal-fired steam plants with scrubbers.

A July 1978 TRW Inc., study performed for TVA states the demonstration step is required to obtain scaleup information, environmental measurements control and other instrumentation requirements, design optimization data, and practical experience with the fluidized-bed combustion units. The manufacturers will need this information to be able to construct a commercial unit meeting the technical specifications of a utility. The study further states that demonstrating the reliability and economic attractiveness of the technology is required to convince the financial community that the fluidized-bed combustion technology is sound. This is necessary for the utilities to obtain reasonable financing rates for utility-size fluidized-bed combustion units.

## DOE'S DELAYING ATMOSPHERIC DEMONSTRATION PROJECT

In January 1977, ERDA contracted with two architectural/engineering firms for separate preliminary designs of a total atmospheric fluidized-bed combustion electric power generating plant. One firm's design was for burning high-sulfur eastern coal while the other design was for burning low-sulfur western coal.

During this same period, TVA, with funds from ERDA, contracted with three boiler manufacturers for preliminary designs of a utility-size atmospheric fluidized-bed boiler. These contracts were to lead to the final design and construction of a large 200-megawatt atmospheric fluidized-bed demonstration plant. TVA's involvement is discussed in more detail in the next section.

Originally, DOE planned to release a solicitation document in October 1977 for the demonstration plant, calling for a 50-50 cost sharing with a private utility. The release of the document was delayed when DOE decided not to include money for the plant in its fiscal year 1979 budget. 1/ The principal reason DOE gave for this action was the discussion of more stringent pollution standards which raised questions of whether atmospheric fluidized-bed combustion could meet the more stringent standards. These proposed standards, which included the 85-percent sulfur reduction requirement, were announced in September 1978. Although the 85-percent sulfur reduction requirement was changed for conventional coal-fired equipment (see p. 2), it was retained in the final regulations issued in June 1979 for those fluidized-bed combustion facilities which are issued a commercial demonstration permit. After further testing, DOE and TVA officials determined that the new EPA standards pose no major problem for fluidized-bed combustion.

DOE officials also told us that a contributing factor in the decision was that as a result of the formation of DOE, the personnel in upper management positions were not familiar with the program and, consequently, were not fully prepared to decide on whether or not to request funds for the demonstration plant.

Utility, architectural engineering firms, and boiler manufacturer officials we contacted identified the 200-megawatt demonstration plant as the key project for

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1/Funding was also not included in the 1980 budget.

commercialization of utility-size atmospheric fluidized-bed combustion boilers. Most were critical of DOE's decision not to request funds for a demonstration plant, because any delay in starting the project will equally delay the plant's going on line. They stated that critical work during the first years of the project requires site-specific evaluations such as environmental impact statements. Environmental work includes monitoring the site for long periods of time, and these time frames cannot be compressed.

## ROLE OF TVA IN COMMERCIALIZATION OF FLUIDIZED-BED FOR UTILITY APPLICATION

Our November 29, 1978, report to the Congress entitled "Electric Energy Options Hold Great Promise for the Tennessee Valley Authority" states that the most significant contribution TVA could make in the area of coal combustion research and development would be to encourage widespread acceptance of fluidized-bed technology. We have found, during this review, that TVA possesses the skilled and experienced personnel and has past and ongoing research activities to vigorously pursue fluidized-bed combustion research and development leading to near-term establishment of a commercially viable demonstration facility. Also, as the Nation's largest utility, TVA is willing and able to assume the leadership role in demonstrating utility applications of fluidized-bed technology as it has historically done in the past with other technologies.

TVA has followed the development of fluidized-bed combustion for several years to determine if it can potentially provide an economic and environmentally acceptable alternative to conventional coal-fired powerplants with scrubbers. A November 1977 study performed by TVA with EPA entitled "Utility Boiler Design/Cost Comparison: Fluidized-bed Combustion versus Flue Gas Desulfurization," determined that atmospheric fluidized-bed combustion has excellent potential for providing an economical and environmentally acceptable alternative to conventional coal-fired powerplants with scrubbers.

As previously discussed in chapter 2, in September 1976, TVA's Board of Directors approved a program leading to design and construction of an atmospheric fluidized-bed combustion demonstration powerplant. An initial $4-million commitment was made for preliminary design, siting, and cost analysis work. After TVA's Board of Directors approved the program, support was sought from ERDA. Consequently, TVA entered into an interagency agreement with ERDA whereby ERDA was to provide an amount not to exceed $1.25 million for three boiler designs. The two agencies have informally agreed,

however, that none of these funds could be used for work dealing with specific sites. A TVA official stated that ERDA feared it would be giving undue competitive advantage to TVA by funding TVA's site-specific work.

In addition to this effort, in May 1978 TVA began a fluidized-bed combustion powerplant siting study for three locations. The study is addressing all aspects of siting, including an environmental impact assessment.

In August and September 1979, TVA awarded contracts valued at $39.5 million for fluidized-bed combustion--$34.7 million to construct a 20-megawatt pilot plant, and $4.8 million for final design of the 200-megawatt demonstration plant.

As stated previously, TVA and DOE already have an interagency agreement for funding preliminary fluidized-bed boiler designs. Also, a memorandum of understanding between the agencies was signed on May 19, 1978, by the Under Secretary of Energy and the Acting General Manager of TVA. The purpose of the memorandum of understanding is to:

> "* * * foster cooperation in research, development, and demonstration projects; the exchange of ideas, information, and data; the utilization of laboratories, equipment and research facilities; and other efforts to further the advancement of knowledge in the general area of energy research, development, and demonstration * * *."

This memorandum of understanding sets forth the basic principles and guidelines for entering into interagency agreements. With basic principles and guidelines already agreed to, it appears that an interagency agreement between TVA and DOE could be negotiated easily for the 200-megawatt demonstration plant.

As with the industrial applications, we are not implying that participation with private industry in demonstration projects should not be pursued by DOE whenever practicable. However, in order to take advantage of TVA's skilled and experienced personnel and past and ongoing experience in fluidized-bed combustion technology, negotiation of an interagency agreement with TVA to host the demonstration plant rather than negotiating a cost-shared contract with a private utility would appear in order. Because proof of reliability of utility-size atmospheric fluidized-bed combustion could benefit all utilities, any added costs over and above TVA's traditional power cost could be federally

funded. These costs could be based on an analysis of TVA's incremental costs for new powerplant construction.

DOE COMMENTS ON USING TVA

In a September 22, 1978, letter to the Secretary of Energy, we asked if there were any legal constraints prohibiting TVA's hosting DOE's atmospheric fluidized-bed combustion demonstration plant. We also requested DOE's general views on the application of the Federal Non-Nuclear Energy Research and Development Act of 1974 (Public Law 93-577) to the issue of eligibility of another Federal agency to assist in demonstration projects under the act.

We were particularly concerned about subsections 4(c) and 8(a) of the act. Subsection 4(c) provides that the ERDA Administrator (now the Secretary of Energy) may, through fund transfers or contracts, advance energy research and development by initiating energy research, development, and demonstration programs utilizing the facilities and expertise of Federal agencies. Subsection 8(a) dealing specifically with demonstration projects authorizes the Administrator to enter into cooperative agreements with non-Federal entities and provide Federal assistance to demonstrate the technical feasibility and economic potential of energy technologies. Specifically, we asked if subsection 8(a) limited eligibility for Federal assistance for demonstration projects to non-Federal entities or may an entity such as TVA be eligible to receive Federal assistance for demonstration projects pursuant to subsection 4(c).

In his December 6, 1978, response, DOE's Assistant Secretary for Energy Technology stated that DOE was not constrained by its general legislation from entering into an arrangement with TVA whereby TVA would host the atmospheric fluidized-bed combustion demonstration plant. However, he stated that the existing authorization by the Congress for the atmospheric fluidized-bed combustion demonstration plant--as a result of a project data sheet included as an enclosure to the Assistant Secretary's letter--depends on participation of non-Federal entities and 50-50 cost sharing. He added, however, that amending the authorization to conduct the demonstration with TVA on an interagency basis was feasible.

We have been unable to find evidence in the project authorization act, the appropriation act, or their legislative histories (including hearings) to support the conclusion that the atmospheric fluidized-bed demonstration plant project was presented to the Congress with a substantive limitation requiring participation of a non-Federal entity

with approximately 50-percent cost sharing. We found that the "participation of non-Federal entities" and "50-percent" "cost sharing provisions" of the project data sheet, referred to earlier, were not submitted to the Congress. Rather, it had been submitted to the Office of Management and Budget as a part of the fiscal year 1978 budget submission, but deleted before the project data sheet was presented to the Congress. Accordingly, these requirements are not binding and there is no need to amend the authorization. Therefore, contrary to DOE's opinion, the Department is not legally constrained from entering into an interagency agreement with TVA, whereby TVA would host the demonstration plant.

## CONCLUSIONS

We believe DOE should intensify its efforts to demonstrate utility applications of atmospheric fluidized-bed technology. The proposed utility demonstration plant is worthwhile and is necessary to convince utilities of the attractiveness of atmospheric fluidized-bed combustion as an alternative to a conventional coal-fired plant with scrubbers. We believe that TVA is a most promising candidate to host the demonstration plant. TVA has proven expertise and experience in implementing new technologies. In regard to atmospheric fluidized-bed combustion, TVA has already completed preliminary design and environmental work and is preparing a program plan for final design, construction and operation of a 200-megawatt demonstration plant.

TVA and DOE already have a memorandum of understanding setting forth the basic principles and guidelines for entering into interagency agreements. With basic principles and guidelines established, it would appear that this interagency agreement between TVA and DOE to host a utility-size fluidized-bed combustion plant could be easily negotiated.

DOE has taken the position that it was not constrained by its general legislation from entering into an arrangement with TVA whereby TVA would host the atmospheric fluidized-bed combustion demonstration plant. However, it believes that the existing authorization by the Congress for the specific demonstration plant depends on participation of non-Federal entities and 50-50 cost sharing. DOE added, however, that amending the authorization to conduct the demonstration with TVA on an interagency basis is feasible.

We have been unable to find evidence in the project authorization act, the appropriation act, or their

legislative histories (including hearings) to support the conclusion that the atmospheric fluidized-bed demonstration plant project was presented to the Congress with a substantive limitation requiring participation of a non-Federal entity with 50-50 cost sharing. We believe, therefore, that DOE is not legally constrained in any way from entering into an interagency agreement with TVA whereby TVA would host the demonstration plant.

RECOMMENDATION

We recommend that the Secretary of Energy enter into an interagency agreement with the Tennessee Valley Authority for hosting the 200-megawatt utility demonstration plant.

# CHAPTER 5

## QUESTIONABLE NEED FOR COMPONENT TEST AND INTEGRATION UNIT

Although we agree with the concept of flexible test facilities, such as component test and integration units (CTIUs) to minimize risk in developing new technologies, we believe they should be constructed at the early stages of development of a technology in order to obtain their maximum benefit. In fiscal year 1976 when designs of atmospheric and pressurized fluidized-bed combustion CTIU's began, the status of the technology was such that the CTIU's would have been useful. At this point, however, the fluidized-bed combustion program is in the latter stages of development and the need for CTIUs is questionable.

When we began our review in mid-1978, DOE's fluidized-bed combustion program included plans for two CTIUs, one for testing atmospheric fluidized-bed combustion, and the other for pressurized fluidized-bed combustion. The atmospheric CTIU was in the early stages of construction while the pressurized CTIU was still in the conceptual design stage.

A 6-megawatt atmospheric CTIU is being built on the campus of West Virginia University in Morgantown, W. Va., to obtain data on bed fluidization, combustion, emissions, and absorbent performance. It will test systems and components at an intermediate-size scale and act as an investigative facility for problems identified in the 30-megawatt pilot project at Rivesville, W. Va.

Cost estimates for design and construction of this facility have steadily increased. The November 1977 estimate of $37 million increased to $42.5 million in April 1978, and to $49.8 million in March 1979. In addition to design and construction costs, DOE has estimated an operation and maintenance expense through the end of fiscal year 1983 of $39.6 million.

DOE had planned to construct a 3-megawatt pressurized CTIU at Argonne National Laboratory, Illinois, at a cost of $25 million to provide a facility for testing and evaluating plant components, control concepts, instrumentation, sampling techniques, and construction material proposed for pressurized fluidized-bed combustion systems. But DOE has decided against construction of this facility because, as stated in its fiscal year 1980 budget submission to the Congress, existing facilities in the United States and the United Kingdom can perform the functions of the CTIU.

We concur with DOE's decision not to build the pressurized CTIU. Before proceeding with the atmospheric CTIU, DOE should determine, as it did for the pressurized CTIU, whether other existing research facilities could accomplish the same purpose. More importantly, there are preliminary indications that the data received may not be generated in time to affect designs of the utility projects; and the boiler manufacturers, whose participation is essential, may not use the units. Each of these matters is discussed in more detail in the following sections.

Although the atmospheric CTIU is already under construction, cancelling the project could still be beneficial to the Government. As of October 1979, only $11.6 million out of the $89.4-million total estimate has been expended, and only $37 million (including the $11.6 million) has been obligated.

The DOE headquarters program manager stated that it would be feasible for DOE to cancel the remaining contracts for the CTIU. He stated that the $11.6 million is primarily for construction of a building to house the boiler. It would appear that although this money has been expended, the building could be sold to the University of West Virginia or modified and used for other purposes. Depending on the time frame, he stated that some portion of the remaining $25.4 million obligated could be recovered.

## UNTIMELINESS OF DATA GENERATED

Preliminary indications are that data from the atmospheric CTIU may not be generated in time to affect designs of the utility demonstration plant if TVA were to host the project. (See ch. 4 for a discussion of why we believe it would be logical for TVA to host the atmospheric demonstration plant.)

TVA states that boiler manufacturers need detailed design information by March 1980 in order to respond to TVA's planned proposal for its demonstration plant. TVA believes that research and development information will be available from the Alliance, Oh., test units and other research and development projects. Late 1981 is the estimated completion date for the atmospheric CTIU and this estimate does not allow for testing prior to beginning routine operations. With a facility as complex as a CTIU, many months will be needed to test the systems before beginning operations, thus adding to the time gap.

## QUESTIONABLE USE BY MANUFACTURERS

To fulfill one of DOE's goals for the atmospheric CTIU, the Department intends to enter into agreements with boiler manufacturers, whereby (1) the boiler manufacturers will provide the various components for testing and (2) DOE will operate and test the equipment. However, we interviewed the three major U.S. boiler manufacturers, whose sales represent approximately 90 percent of the boiler sales market, concerning the CTIU, and they expressed little optimism about its usefulness. One boiler manufacturer official explained that the CTIU is a useful research tool but will not come on line soon enough to input into the utility demonstration program. Another told us that his company has no plans to use a CTIU, stating that the company would have to delay its research schedule to be able to use a CTIU. He also said that manufacturers would rather use their own test facilities to develop data on their components, especially since they will have to guarantee these products before marketing them. It appears, therefore, that since the major manufacturers have their own test facilities, they will probably just use them instead of the CTIU.

## EXISTENCE OF OTHER TEST FACILITIES

In view of our questions concerning the timeliness and use of the atmospheric CTIU, we believe that DOE should determine, as it did for the pressurized CTIU, whether the tests planned for this facility could be performed at other existing research facilities. Preliminary indications are that there are existing test facilities available to perform the majority of the tests planned for the atmospheric CTIU. Availability of test results should not be a problem since most of the existing test facilities are Government owned and those that are privately owned belong to DOE contractors.

Four of the five demonstration plant contracts in DOE's industrial atmospheric fluidized-bed combustion program call for construction of flexible test units to provide data for design and construction of the industrial demonstration plants. The other contract did not include a test unit because the architectural engineering firm working on the project already was operating the Alexandria, Virginia, Government-funded test unit discussed below. With the data and experience from these industrial test units and demonstration plants, questions such as types of coal feed systems and operating procedures should be answered before the proposed CTIU's are even constructed.

In addition, since there has been a delay of about 4 years in the introduction of the CTIUs, some of the testing planned for the CTIUs is already being done at other facilities. DOE and others, such as the Electric Power Research Institute, are funding this research at existing facilities in the United States. Among at least 16 existing facilities are

--the atmospheric test unit in Alexandria, Va., which is being used to test a wide range of fuels and operating modes;

--the Rivesville, W. Va., atmospheric pilot plant which has been reprogrammed to do many of the tests, including coal feed systems, originally planned for the atmospheric CTIU; and

--atmospheric test units in Alliance, Oh., which are testing aspects of limestone utilization for sulfur dioxide removal and coal and limestone characteristics.

## CONCLUSIONS

We agree with the concept of flexible test facilities to minimize risk in developing new technologies. However, test facilities such as CTIUs should be constructed at the early stages of a technology's development. When design of the atmospheric CTIU began in fiscal year 1976, atmospheric fluidized-bed combustion was considered to be in the early stages of development. The technology is now in the advanced stages of development and the CTIU is still not in operation. Because (1) the data received from the CTIU may not be generated in time to affect designs of the utility projects; (2) the manufacturers, whose participation is essential, may not use the unit; and (3) indications are that the tests planned for the CTIU could be performed at other existing research facilities, we believe DOE should seriously reevaluate its plans for the CTIU.

We recognize that the construction contract for the building to house the test unit is almost completed, and that other contracts have been let with funds committed. But in light of the CTIU's questionable need and application, we believe that the Department could sell the building or make modifications and find other uses for it. We further believe that the Department should determine the costs, benefits, and options for terminating the remaining contracts.

RECOMMENDATION

We recommend that the Secretary of Energy reevaluate the costs and benefits of continuing its plans for the test facility being constructed in Morgantown, West Virginia, including options for terminating the contracts and selling or modifying the facility for other uses.

## CHAPTER 6

## AGENCY COMMENTS

We sent drafts of this report to DOE, TVA, Defense, and the Air Force. TVA, Defense, and the Air Force generally agreed with the report and provided only informal comments. By letter dated June 18, 1979, DOE provided formal comments. (See app. I.) DOE agrees with our statement that "* * * the Department should accelerate its fluidized-bed combustion program in order to demonstrate the technology's reliability as soon as possible." However, DOE questions whether our recommendations would achieve this goal. DOE's concerns relate to our recommendations to

- --demonstrate the technology in Defense industrial plants;
- --pursue a utility-size demonstration plant with TVA; and
- --consider terminating the contracts for the conponent test and integration unit at Morgantown, W. Va.

DOE also raised some environmental concerns regarding the technology.

### DEMONSTRATING THE TECHNOLOGY IN DEFENSE INDUSTRIAL PLANTS

In its June 18, 1979, letter, DOE disagrees that placing demonstration boilers in Defense industrial plants would accomplish the two advantages cited in a draft of this report: (1) that the demonstration units could be brought on line earlier and (2) that the Government would be getting the most for its investment because demonstration units would replace outdated boilers. DOE claims there is no demonstrated reason to believe that Defense can get atmospheric fluidizied-bed combustion on line any faster than the current approach. DOE also questions whether the Government would get the most from its investment since it doubts if the project would convince users to adopt fluidized-bed combustion in their own operations. DOE maintains that demonstrations in energy-intensive industries are needed to show credibility of the cost performance and reliability of fluidized-bed combustion units.

Although all past attempts at negotiating a contract with an industrial partner for an atmospheric fluidized-bed demonstration plant have failed and this could affect the timing of future demonstration units, we have deleted

specific reference to the Defense approach as bringing the units on line earlier. It is not our intention to discourage DOE from continuing to pursue industrial participation in its program; however, in view of (1) past difficulties in reaching agreement with an industrial partner and (2) the Department of Defense's willingness and enthusiasm for participating in the program, we continue to believe that DOE should pursue the complementary strategy of placing a demonstration unit at a Defense industrial plant. There is also the added advantage, assuming successful operation, that the demonstration boilers could serve as replacement boilers for oil, gas, or outdated coal-fired boilers.

In regard to the credibility issue, we found that most of the industrial users and boiler manufacturers felt that demonstration would be effective regardless of the type of industry selected, as long as the site uses the boiler on a continuous basis and produces steam for industrial application. Because Defense sites use industrial-size boilers continuously to produce steam for their industrial activities, we believe that a Defense demonstration would have credibility with industry and would allow the Government to receive the most for its investment.

The Air Force believes that a successful joint DOE/Air Force demonstration of an advanced combustion technology boiler at its showcase installation--McClellan Air Force Base, California--will significantly accelerate the commercialization of fluidized-bed combustion and additionally provide the Air Force with firsthand knowledge for the successful replacement of other central heating plants at Government-owned Defense industrial installations.

McClellan would constitute an ideal location for the demonstration of fluidized-bed combustion technology. It is located within a metropolitan area comprised of industry, agriculture, and State government activities. The base is responsible for major aircraft, missile, space program, and electronic systems overhaul, warehousing, and distribution. It could be compared to a small industrial city of approximately 25,000 people. Industrial activities located at McClellan include metal plating and coating, aircraft maintenance and overhaul facilities, equipment painting, and automated warehousing, storage, and distribution.

McClellan presently has a requirement to replace its old and deteriorated boilers in the central heating plants. The Air Force believes that installing fluidized-bed boilers will satisfy its replacement problem as well as demonstrate reliability of the technology. It states that successful

demonstration of the technology, under the rigid California and Sacramento area pollution control regulations, would validate the concept to the most skeptical industrial user.

DOE's letter also raised the physical security problem inherent in Defense installations, questioning whether the demonstration boiler would be readily accessible to the boiler community. An official in the Air Force's Director of Engineering and Services office stated that boiler plants are normally off limits to unauthorized personnel. He stated, however, that if an Air Force base installed a demonstration boiler, the Air Force would most certainly make provisions to allow visitors like the boiler community to have access to it.

## PURSUING A UTILITY-SIZE DEMONSTRATION PLANT WITH TVA

In its June 18, 1979, letter, DOE indicates that it now agrees that a cooperative agreement with TVA to pursue a utility-size atmospheric fluidized-bed combustion demonstration plant is feasible. However, DOE states that because of the status of TVA's program, the earliest a TVA demonstration plant can be built is 1986. Because of TVA's considerable past research and development efforts and in-house expertise in atmospheric fluidized-bed combustion, we believe this time frame is competitive with that of other utilities. Also, TVA and DOE already have a memorandum of understanding setting forth the basic principles and guidelines for entering into interagency agreements. With basic principles and guidelines established, it would appear that an interagency agreement could be easily negotiated.

We also believe that DOE is not giving TVA due credit for the advances TVA has made in its program. In September 1979, TVA awarded a contract of $34.7 million to construct a pilot plant which is scheduled for completion by January 1982. Also, in August 1979, $4.8 million in contracts were awarded for final design of the demonstration plant.

The Electric Power Research Institute's Program Manager for Development of Fluidized-Bed Combustion whole-heartedly endorses TVA's program. He stated that the institute has been working hand in hand with TVA and will assist TVA in any way it can.

DOE's letter stated that it is questionable whether utility-scale atmospheric fluidized-bed combustion should be demonstrated because the major support by the utility industry to date has been directed to pressurized fluidized-bed combustion. As a result, DOE claims that even if

demonstrated, utility-scale atmospheric fluidized-bed combustion may not be used commercially.

TVA's Program Manager stated that it is difficult to compare and even more difficult to interchange the applications of atmospheric and pressurized fluidized-bed combustion systems. For example, the benefits of a pressurized system are only realized if a combined-cycle unit is required; some utilities do not have a need for a combined-cycle system. He stated that factors such as the amount and types of industry nearby, the geographical location of the proposed plant, and water availability must also be weighed before deciding on whether to use an atmospheric or combined-cycle pressurized system. EPRI's Program Manager reiterated TVA's position.

TVA's Program Manager also discussed the timing factor. He stated that there is a 50-percent probability that 1,000 to 2,000 megawatts of additional generating capacity will be needed by 1994. He stated that although atmospheric fluidized-bed combustion could be commercialized by then, it is extremely doubtful whether pressurized will be.

In view of these discussions, we believe that the successful demonstration of atmospheric fluidized-bed combustion in a utility could lead to commercial use of the technology and that this effort could be accelerated if TVA were to host the demonstration plant.

## QUESTIONABLE NEED FOR COMPONENT TEST AND INTEGRATION UNIT

DOE's letter states that the CTIU is necessary because (1) it will be the first facility of its kind in operation using a stacked-bed design 1/ and two of the three major U.S. boiler manufacturers now prefer its type of design; (2) it will be the first large, flexible test facility; and (3) DOE will lose credibility if it terminates the project.

We agree that the CTIU will be the first stacked-bed boiler in operation, and that two out of the three major boiler manufacturers do prefer its design to others. But, after discussions with officials of the three major boiler manufacturers, we cannot agree that the uniqueness of the CTIU's design is that key an issue. Only one of the three

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1/In a "stacked-bed," the components (beds) are stacked vertically while the beds of other existing fluidized-bed test units are lined up horizonally.

major boiler manufacturers indicated any intention of using the CTIU, and this particular manufacturer is the one not using the stacked-bed design. Also, the boiler manufacturers stated that the primary reason for a stacked-bed design is not of a technological nature but to reduce the floor space taken up by the boiler.

With the exception of one existing test unit, DOE's letter states that all other test units are too small to provide meaningful data and that no existing test units are flexible enough to accomplish the CTIU's mission. However, the boiler manufacturers stated that there are only two major questionable issues of fluidized-bed combustion--coal-feed into the boiler and overall operational reliability. They stated that these issues can be demonstrated with DOE's industrial demonstration projects. For example, the coal-feed problem could be resolved by the Georgetown University project. The boiler manufacturers added that "chemistry" related issues such as optimum bed depth and emissions data can be tested sufficiently in the smaller existing test units.

DOE is concerned about losing credibility with future contractors if it terminates the project. While we appreciate DOE's concern for its credibility, we believe the main issue is the need for the facility. We do not believe it prudent to spend $89.4-million (operations costs included) on a project which may only be used as a backup test unit because some credibility may be lost. Only $11.6 million out of the $89.4 million has been expended and only an additional $25.4 million has been obligated. Depending on the time frame, a significant portion of latter amounts could be recovered.

## ENVIRONMENTAL ISSUES

DOE's June 18 letter discusses four environmental issues concerning fluidized-bed combustion: (1) particulate control, (2) waste disposal, (3) nitrogen oxide emissions; and (4) water savings. We believe that these issues need additional attention but that in some cases, they have been overstated.

### Particulate control

DOE states that fluidized-bed combustion can potentially generate a large volume of particulates. DOE states that although particulates may present a problem for pressurized fluidized-bed combustion, they can be controlled by atmospheric fluidized-bed units. We agree with DOE and wish to point out that our report makes

recommendations only concerning atmospheric fluidized-bed combustion.

Waste disposal

DOE states that there is some question as to how much of the waste product can be utilized when compared to the volume generated, but that it will present no more of a concern than the waste products of conventional coal-firing with scrubbers. DOE's letter did not acknowledge that the Department has studies underway to analyze the agricultural and non-agricultural uses of fluidized-bed waste material. Also, even if all the fluidized-bed waste material cannot be utilized, it certainly will present less of a disposal problem than the wet sludge of a scrubber since, being a dry product, it can be transported more easily.

Nitrogen oxide emissions

DOE's letter questions the benefits of lower nitrogen oxide generation attributed to fluidized-bed combustion. DOE takes this position because, since fluidized-bed combustion systems do not inherently generate desired fuel efficiency, unburned carbon must be reclaimed through a carbon burn-up cell. The carbon cell burns at higher temperatures and generates higher levels of nitrogen oxide than the fluidized-bed unit.

While we do not disagree with the statement regarding burning temperature of the carbon burn-up cell, we do disagree with DOE's statement that the benefits of lower nitrogen oxide are questionable. DOE's comment in this area is inconsistent with its own published documents and differs with reports of industrial groups discussed elsewhere in this report. In its own March 1979 Fossil Energy Program Summary Document, DOE states that fluidized-bed combustion shows potential for improving efficiency while lowering emissions of nitrogen oxide. Further, a DOE fact sheet, in discussing the CTIU which has a carbon burn-up cell, states that because of the low operating temperatures, the nitrogen oxide emissions will remain far below the standard levels.

Water savings

The DOE letter's last point deals with water savings, stating that there will be only minimal savings of water--only 7 to 10 percent. We believe a 7- to 10-percent water savings could be very significant, especially when these savings are multiplied by a number of new plants. Also,

because of the tremendous potential need for water caused by building other fossil energy projects, any possible water savings should be carefully considered.

## CHAPTER 7

## SCOPE OF REVIEW

We conducted our review primarily at DOE offices in Washington, D.C., and with contractors responsible for design, construction, and operation of fluidized-bed combustion projects. We reviewed legislation and literature pertinent to fluidized-bed combustion, and observed the operation of various test facilities.

We also obtained comments regarding fluidized-bed combustion from officials in

--other Federal agencies including the Tennessee Valley Authority, Environmental Protection Agency, the Department of Defense, and Office of Management and Budget;

--the State of Ohio's Energy Research and Development Administration and Environmental Protection Agency;

--Battelle Columbus Laboratories;

--American Electric Power;

--two trade associations (National Coal Association and American Boiler Manufacturers Association);

--six boiler manufacturers;

--three architectural engineering firms; and

--five major industrial plants.

APPENDIX I

Department of Energy
Washington, D.C. 20545

June 18, 1979

J. Dexter Peach, Director
Energy and Minerals Division
U. S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

We appreciate the opportunity to review and comment on the GAO draft report entitled "Fluidized-Bed Coal Combustion -- How It Can Be Accelerated." Our views with respect to the text of the report and recommendations contained therein are discussed below.

While we agree with the general thesis "that the Department should accelerate its fluidized-bed combustion program in order to demonstrate the technology's reliability as soon as possible," we cannot agree that the recommendations would achieve this goal.

Looking first at industrial atmospheric fluid-bed combustion (AFBC), the report indicates that the defense plant approach has two advantages: (1) that the demonstration units could be brought on-line earlier, and (2) that the Government would be getting the most for its investment because the demonstration units would replace outdated coal boilers.

With respect to the earlier on-line time, there is no demonstrated reason to believe that a defense agency can specify, design, construct, and operate an atmospheric fluidized-bed boiler any faster than a private firm working through a DOE cost-shared contract.

The second suggested advantage, getting the most from the investment, would be true only if the demonstration of an AFBC unit in a defense industrial plant could be considered the equivalent of an on-line commercial demonstration for one of the suggested process industries. We believe the project must show credibility of the cost, performance, reliability, and also other data to the potential users. The project must also show the effectiveness of the demonstration in convincing users to adopt AFBC in their own operations.

Due to the critical nature of boiler plant operations in most industrial facilities, particularly the continuous process industries, many users indicate the most effective commercial demonstration would be in their own facilities or closely allied facilities in a related industry. Since the objective of the AFBC program is commercial use and operation, it may be false economics to risk attainment of the objective in order to minimize boiler replacement costs at an existing Defense facility. Physical security would also be a problem since Defense installations are not readily accessible to the boiler community and technology transfer is constrained by national security.

A cooperative agreement with the Tennessee Valley Authority (TVA) to pursue an AFBC utility demonstration plant is feasible. However, the TVA program calls for a pilot plant and a demonstration plant, in parallel, with commitment to construction contingent on satisfactory data from the pilot plant. As of May 1978, the pilot plant is only an identified need and a concept. No conceptual design exists; size has not been determined; beds configuration determination in needed and other key configurations is lacking. As a result of these deficiencies, the earliest the TVA demo can be built is 1986, assuming full cooperation of Congress and all interested sources.

It is suggested in the report that a utility-scale demonstration of AFBC technology, in the current stage of technology development, would be useful in leading to adoption and commercial use of AFBC by the utility industry. A recent DOE task force study concluded that the AFBC technology was not ready for commercialization at the utility scale. The major support by the utility industry to date has been directed at pressurized fluidized-bed combustion because of the potentially higher overall thermal efficiency achievable with pressurized units. It is therefore questionable whether utility-scale atmospheric units, if demonstrated, would actually be used commercially.

The report appears to agree with the concept of a flexible research test facility but questions the Component Test and Integration Unit (CTIU) in light of timing and the potential use of other facilities. The CTIU facility provides, at a minimum, the capability to perform back-up and technology-improvement testing, if ongoing and proposed industrial AFBC units encounter unanticipated technology problems. In addition, this facility should provide considerable performance prediction data for design of AFBC units on varying types and qualities of coals and mixed fossil-fuel feedstocks.

The CTIU is based on the premise that AFBC technology will continue until well into the next century. It will be on line before the TVA pilot plant and will be the first stacked bed unit. Two of the three U.S. utility boiler manufacturers prefer the stacked bed and the third was influenced in his decision not to stack by his desire to reduce unknowns and risks by sacrificing cost.

With the exception of the Electric Power Research Institute/Babcock & Wilcox (EPRI/B&W) 6' X 6' bed unit, other potential AFBC facilities are not suitable for the CTIU mission because they are too small. Several studies have shown that the 6 foot size is the smaller size in which we are independent of wall effects. This is why EPRI projects were jointly planned by Energy Research and Development Administration (ERDA) and EPRI. The Combustion Engineering, Alexandria, FluiDyne and B&W subscale bed units are all approximately 3 feet in cross section and are inexpensive units adequate for obtaining confidence and general data for early industrial units. These subscale units are versatile but not flexible; that is, they can be operated over a range of some parameters but cannot test important changes in configuration such as deep beds, high freeboards, and heat recovery heat exchangers. The component test and integration unit is both flexible and versatile. The Environmental Protection Agency (EPA) has given it a strong endorsement as the only facility in which they can get credible data to set future standards for first, and later generation, fluidized beds.

The industrial demonstration units are neither flexible nor versatile and are instrumented for little more than basic performance data. The extensive instrumentation at the component test and integration unit will enable us to get bed profile data so as to see if further reductions in sulfur dioxide and nitrogen oxides can be obtained and to get transient dynamic data, needed for load following and emergency mode operation.

The CTIU facility will enable DOE to test improved components and isolate effects and test under reproducible, comparable conditions. A difficulty exists with the component test and integration unit because the manufacturers keep proprietary data to themselves. Clarification of Government policy would increase industrial interest in using the facility. Industry sees the industrial AFBC market as highly competitive, and they are reluctant to be involved with the development of improved industrial scale components with their competitors. While each manufacturer wants his own development unit, the Nation cannot afford many.

As previously stated, the EPRI/B&W 6' X 6' bed unit is the only other unit of sufficient scale to provide data applicable to utility designs. However, it is basically a single cell, combustion, and sulfur dioxide absorbtion research unit and does not address the other engineering questions that the CTIU does. To expand the EPRI/B&W facility would require building another component test and integration unit. Canceling of the CTIU has two aspects: (1) saving of investment on a questionable facility, as discussed in the report; and (2) DOE credibility. The report does not discuss the loss of credibility by DOE in terminating partially constructed projects. There is a question as to whether participants of this, and other projects, will continue to cooperate and participate without a reasonable assurance of DOE support. This would have long range implcations on the entire DOE program.

Also, in regard to fluidized-beds combustion, the environmental aspects need to be considered. Fluidized-bed combustion offers an alternative to utilize our high sulfur coals. The technology is constrained by particulate controls and solid waste disposal. Although particulate control was not discussed in the report, EPA is considering a particulate New Source Performance Standards emission standard for utilities. This standard would be proposed on the same approximate schedule as the proposed accelerated Fluidized-Bed Combustion program which would include a utility demonstration plant. Fluidized-Bed Combustion has the potential for generating a larger volume of particulate than conventional combustion. Cyclones and electrostatic precipators have not been demonstrated to be effective on atmospheric fluidized-bed combustion. However, we feel adequate technology is available to control AFBC particulates at this time, Although there may be a particulate control problem with pressurized fluidized-bed combustion.

There is some question how much spent sorbent from fluidized-bed combustion can be utilized as by-product when compared to the volume generated. We do not feel the ash and spent sorbent will create a greater concern than bottom ash, fly ash, and scrubber sludge from conventional coal combustion in land fill disposal.

The proposed benefits of lower nitrogen oxides generation are questionable. To obtain the desired fuel efficiency, unburned carbon from the spent material must be reclaimed thru a carbon burn-up cell. Carbon burn-up cells burn at higher temperatures and will generate higher levels of nitrogen oxides than the fluidized-bed combustion unit.

The proposed water saving by fluidized-bed combustion is questionable. The report suggested additional water savings in the arid Western U.S. Coal from the West is low in sulfur and will require minimal scrubbing for sulfur control. Our information indicates the water saving of AFBC will also be minimal (i.e., 7-10%) in comparison to the total requirement.

We appreciate your consideration of these comments in the preparation of the final report and will be pleased to provide any additional information you may desire.

Sincerely,

Donald C. Gestiehr
Director
Office of GAO Liaison

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