REPORT OF THE COMPTROLLER GENERAL OF THE UNITED STATES

Plans For Construction Of A Magnetohydrodynamics Test Facility In Montana

Energy Research And Development Administration

This is GAO's analysis on matters concerning the construction and operation of a magneto hydrodynamics test facility in Montana and its conclusion that the Congress intended the Energy Research and Development Administration build two such facilities in Montana - the component development and integration facility and later the engineering test facility.

Because of this congressional mandate, the Energy Research and Development Administration did not make any analysis to determine whether it would be more advantageous to build either of these facilities in a State other than Montana.

EMD-76-8

SEPT. 1, 1976

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

B-178205

The Honorable Marilyn Lloyd
House of Representatives

Dear Ms. Lloyd:

In response to your April 9, 1976, request and later discussions with your office, we reviewed certain aspects of the Energy Research and Development Administration's magnetohydrodynamics program plans for the construction and operation of the component development and integration facility in Butte, Montana.

Your major concern appears to be whether the Energy Research and Development Administration is justified in constructing the component development and integration facility in Montana rather than at an existing Energy Research and Development Administration-funded magnetohydrodynamics facility. Our review clearly shows that the Congress intended that the Energy Research and Development Administration build two facilities--the component development and integration facility and later an engineering test facility--in Montana. Because of this congressional mandate, the Energy Research and Development Administration did not make any analysis to determine whether it would be more advantageous to build either of these facilities in a State other than Montana. Details of our findings are in appendix I.

We discussed the matters presented in the report with agency officials and have considered their comments in this report.

Sincerely yours,

ACTING Comptroller General
of the United States

REVIEW OF SELECTED ASPECTS OF PLANS FOR THE CONSTRUCTION OF A MAGNETOHYDRODYNAMICS TEST FACILITY IN MONTANA

INTRODUCTION

To help improve the energy picture, the Nation is attempting to reduce its reliance on oil and natural gas for electric power generation by, among other things, increasing the use of its abundant coal reserves. Burning more coal, however, will also increase air and water pollution.

For a number of years, the Federal Government, anticipating an increased use of coal, has been funding programs to make coal a cleaner source of energy. In the past, it emphasized processes, like gasification and liquefaction, designed to convert coal to cleaner fuels. Now it has expanded its efforts to include technologies designed to convert coal energy to electricity more efficiently than conventional powerplants do. In this way, the same amount of electricity could be generated using less of the polluting fuel. An electrical generator operating on the principle of magnetohydrodynamics, or MHD, is one such technology.

DEVELOPMENT OF MHD

An MHD generator functions by causing a hot, electrically conductive gas or liquid to interact with a magnetic field. MHD systems are not expected to be very efficient alone. As a result, MHD is generally thought of as an initial stage, or topping unit, for a conventional steam powerplant. Two electric generating systems are required--the MHD system and the steam system.

Although the United States has chosen to base its development programs on coal, MHD is not limited to any particular fossil-fuel source to generate electricity. Development programs in the Soviet Union are based on natural gas and in Japan, on oil.

MHD systems have not yet achieved high power levels (measured in electrical megawatts) for long periods of time (measured in hours). The most successful demonstration to date has occurred in the Soviet Union. Since March 1971 the Soviet Union has been operating a natural gas-fired MHD pilot plant. Recently, the plant achieved a power level of 20.4

megawatts for about 30 minutes. In a previous operation, the plant supplied electricity to Moscow for 100 hours at power levels up to 6 megawatts.

In the United States the most successful demonstration to date has been an experimental MHD generator at AVCO Everett Research Laboratory in Everett, Massachusetts. It achieved a power level up to .25 megawatts for about 100 hours. The test, however, only simulated coal combustion. It was run using a liquid fuel with some coal added.

The most successful demonstration using 100 percent coal occurred during a test at the University of Tennessee Space Institute of the only experimental MHD generator in the United States capable of processing 100 percent coal. It has achieved a power level up to .10 megawatts for about 1 hour.

Both performance and durability of MHD generators must be greatly improved over present demonstrated capability. As discussed further on page 8, section 107 of Public Law 93-404 requires the Energy Research and Development Administration (ERDA) to plan for the construction of at least a 500-megawatt MHD plant for possible operation in the mid-1980s. A coal-fired, combined MHD and steam powerplant with a MHD subsystem providing about one-half (250 megawatts) the plant's power output and commercial operating times up to 5,000 hours is required to carry out the congressional mandate. Compared to demonstrated capability of MHD systems, the increased requirements would be

--12.3 times more power than the best performance of the Soviet natural gas-fired plant and about 41.7 times more power than its best 100-hour operation,

--1,000 times more power than the best performance of the AVCO generator during a 100-hour test operation, and

--2,500 times more power than the best performance of the University of Tennessee generator during a 1-hour test operation.

Along with solving other technological problems, ERDA's MHD program is aimed at increasing the performance and durability of MHD systems.

ERDA'S MHD PROGRAM

Continuous Federal sponsorship of MHD research for electric utility application began early in the 1970s with the

Office of Coal Research, U.S. Department of the Interior. This program, along with MHD projects sponsored by the Bureau of Mines and the Atomic Energy Commission, was transferred to ERDA in January 1975.

In response to congressional intent that MHD development move more rapidly, ERDA's program has been vastly accelerated. Funding for MHD development was increased as shown below.

Fiscal year	Funding	Estimate of constant dollars (1971 base year) (note a)
	(millions)	
1971	$ 0.5	$ 0.5
1972	0.9	0.8
1973	3.5	3.0
1974	7.8	6.3
1975	14.3	10.3
1976 (note b)	49.5	32.7
Transition quarter (note c)	7.8	4.9
1977 (estimated)	37.4	22.3
Total	$121.7	$80.8

a/Figures are based on Department of Commerce indexes and our estimates for fiscal year 1976, transition quarter, and fiscal year 1977.

b/Includes $20 million reprogramed from other ERDA programs to the MHD program.

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

The fiscal year 1977 estimate is 10.5 percent of ERDA's total coal research operating expense budget request submitted to the Congress. In 1975 MHD funding represented 5 percent of the Federal coal research budget.

Although ERDA's MHD program is one of several advanced power generation programs, it is the only one of these programs to achieve division status within ERDA. In September 1975 the Division of MHD was established to give added stature to the program. Staffing of the program was increased as shown below.

As of	Authorized	Actual
April 25, 1975	5	4
June 30, 1976	24	21

The goal of ERDA's MHD program is to design, construct, and operate a combined MHD and steam commercial demonstration plant by 1989. ERDA's strategy is to shift emphasis from past exploratory and scientific approaches to an engineering-oriented program directed toward operation of at least a 500-electrical-megawatt commercial demonstration plant. The program consists of three overlapping phases, each focused on specific development requirements ERDA believes necessary for commercial demonstration. During each of the three program phases, ERDA expects to construct and operate at least one test facility.

The first or current phase began in 1976 and extends through 1985. It involves developing the technology to design and test alternative components of the MHD subsystem on an intermediate scale, about 50 thermal megawatts (2 to 3 electrical megawatts). 1/ The component development and integration facility (CDIF) is scheduled to be constructed and operated during this phase.

The second phase is scheduled to begin in 1977 and extend through 1989. It involves developing the technology to demonstrate the efficiency and prove the endurance of a complete MHD and steam powerplant on a pilot-scale level, about 250 thermal megawatts (80 to 100 electrical megawatts). The engineering test facility (ETF) is scheduled for construction and operation during this phase.

The third or final phase is scheduled to begin in 1982 and extend beyond 1990. It involves demonstrating the commercial feasibility of a combined MHD and steam powerplant. During this final phase a commercial demonstration plant to operate at approximately 1,000 thermal megawatts (500 electrical megawatts) is scheduled for construction.

As of May 3, 1976, ERDA's MHD Division had entered into contracts at a total cost of $77.4 million. Of this amount, $10.4 million (13.4 percent) is for the design, construction,

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1/A thermal megawatt is a measure of heat capacity, and an electrical megawatt is a measure of electrical output.

or operation of the CDIF and its land acquisition. Contracts to organizations carrying out major hardware test programs of MHD components in the United States account for $37.7 million (48.7 percent) as shown in the following table.

Major ERDA-Funded MHD Facilities

Facility location	Existing or planned MHD system capacity (note a)	Contract amount as of May 3, 1976
	(thermal megawatts)	(000 omitted)
Arnold Engineering Development Center, Arnold Air Force Station, Tennessee	250 to 300	$ 6,635
AVCO Everett Research Laboratory, Everett, Massachusetts	20.0	8,724
Pittsburgh Energy Research Center, Pittsburgh, Pennsylvania	5.0	8,830
Reynolds Metals, Alabama	6.5	b/0
Stanford University, Stanford, California	8.0	2,031
University of Tennessee Space Institute, Tullahoma, Tennessee	21.0	8,151
Westinghouse Research and Development, Pittsburgh, Pennsylvania	4.5	3,335
Total		$37,706

a/ERDA rates facilities by their heat capacity (thermal megawatts) rather than their electrical output (electrical megawatts) because the objective of the tests at these facilities is not to maximize power output. In addition, not all the facilities have components for converting fuel to electricity.

b/At the time of our review, ERDA was negotiating a contract with Reynolds Metals.

The remaining $29.3 million (37.9 percent) is for supporting MHD research by other universities and research organizations.

According to ERDA officials, although coal has been chosen as the primary fuel for MHD power generation, no performance data exists on the relative advantages and disadvantages of eastern and western coals in the MHD process. As mentioned previously, the only 100 percent coal-fired MHD generator is at the University of Tennessee Space Institute. Primary emphasis has been on using eastern coal to fuel this generator. A project is underway to gather some performance data on western coal with this generator. Liquid hydrocarbon fuels, such as toluene and benzene, have been used for component development at most ERDA-funded MHD facilities.

CDIF: STATUS OF CONSTRUCTION AND OPERATION PLANS

The CDIF is being constructed primarily to provide MHD engineering test data ERDA believes critical to the design of components and subsystems for much larger facilities. It will be a Government-owned, contractor-operated facility, consisting of a complex of several buildings--main test building, operations building, office building, warehouse, and various supply buildings. This facility will be used to

- --test engineering developments and proof prototype MHD components on an intermediate scale (50 thermal megawatts),
- --study the interactions associated with the integrated operation of key MHD components and subsystems before scale-up to the pilot-plant-size engineering test facility (about 250 thermal megawatts), and
- --conduct follow-on research programs during its estimated 15- to 20-year life.

Construction plans

The following milestones for the design and construction of the CDIF have been achieved.

- --In December 1975 (1) a 93-acre site located in an industrial park near Butte, Montana, was selected for construction of the CDIF and (2) an agreement with Argonne National Laboratory for conceptual design was entered into ($1.9 million).
- --In March 1976 a contract to provide architect and engineering services was awarded to Ralph M. Parsons Company, Pasadena, California ($5.377 million).

--In May 1976 (1) an agreement to acquire land for the plant site was signed ($37,000), (2) a 9-month contract for site preparation and construction of office and warehouse buildings was awarded to a local Montana firm ($2.0 million), and (3) groundbreaking ceremonies were held at the site.

Selection of the facility construction contractor is scheduled for September 1976, with construction scheduled to begin in spring 1977 and be completed by May 1978 ($21 million).

Operation plans

Once the facility is constructed, ERDA plans to designate the Montana Energy and MHD Research and Development Institute, Inc., as the contractor operator (facility manager). The institute is a non-profit Montana corporation created in 1974 to act as the legal agent for schools in the Montana university system.

On March 18, 1975, ERDA awarded a $1.708-million sole source contract to the institute for work by two subcontractors--Montana State University and Montana College of Mineral Science and Technology. Recognizing that no prior MHD work had been undertaken by any organization in Montana, ERDA entered into this contract for the purpose of developing the institute's technical capability to operate the CDIF. On October 1, 1975, the contract amount was increased by about $992,000 to prepare the institute for management of the CDIF and for other MHD-related research. The contract amount was then increased on May 19, 1976, by $464,000 additional, bringing the total to about $3.166 million.

The first component testing is scheduled to start in July 1978. None of the major components, however, have yet been developed or acquired.

JUSTIFICATION FOR PROCEEDING WITH CONSTRUCTION IN MONTANA

According to ERDA, a facility of the nature and scope of the CDIF has been included in the planning of the Federal MHD program since 1972. On August 31, 1974, while the program was under the Office of Coal Research, Department of

the Interior, the Office received the following appropriation and congressional mandate in section 107 of the Department of the Interior and Related Agencies Appropriation Act, 1975, Public Law 93-404, 88 Stat. 803:

> "SEC. 107. The sum of $261,278,000 appropriated under the head, Office of Coal Research, Salaries and Expenses, in Public Law 93-322, [the Special Energy Research and Development Appropriation Act, 1975] signed June 30, 1974, includes $12,500,000 for a program for magnetohydrodynamics (MHD), of which $5,000,000, as described in Senate Report 93-903 and House Report 93-1123, shall be used in part to initiate design of an MHD engineering test facility, and there shall be undertaken immediately the design and planning of such engineering test facility, to be located in Montana, large enough so as to provide a legitimate engineering basis which when achieved will enable the immediate construction of a commercial scale MHD plant (500 MWe or above) for possible operations in the mid-1980s." (Underscoring added.)

This provision had been added by the Senate Committee on Appropriations, which described it as follows:

> "The Committee has included language in the bill establishing the high priority for magnetohydrodynamics (MHD) research specified earlier in the Special Energy Research and Development Appropriations Bill. Specifically, the language directs the Office of Coal Research to undertake immediately the design and planning of a commercial-scale engineering test facility in Montana, adjacent to western coal fields, in cooperation with the Montana College of Mineral Science and Technology. It is the Committee's view that research in MHD holds the greatest promise for the clean conversion of coal to energy." S. Report. No. 93-1069, 21 (1974). (Underscoring added.)

As cited above, the legislative history of the Special Energy Research and Development Appropriation Act, 1975, Public Law 93-322 (June 30, 1974), 88 Stat. 276, was incorporated into the $12.5-million Office of Coal Research fiscal year 1975 MHD appropriation. The Senate Committee on Appropriations, in adding to the amount initially requested, in the special appropriation reported as follows:

> "The Committee was concerned that, in an otherwise vastly accelerated program, the request of $7,500,000 for MHD research was held to the same approximate level as 1974. The additional $5,000,000 recommended by the Committee will initiate work on an MHD engineering test facility and provide additional research on MHD techniques and applications at the Montana College of Mineral Science and Technology and other units of the Montana University System." S. Report No. 93-903, 18 (1974).

The conference retained the increased amount recommended for MHD,

> "to initiate design and planning work on an engineering test facility and to provide for additional research on MHD techniques and applications at the Montana College of Mineral Science and Technology and other units of the Montana University System." H.R. Conf. Rept. No. 93-1123, 4 (1974).

MHD program managers had two alternatives available at this time

1. initiate design and construction of the engineering test facility immediately or

2. accelerate design and construction of the CDIF.

The latter alternative was selected because the CDIF was believed to be critical to solving technical problems associated with scaling up to the pilot-plant-size engineering test facility. This belief, according to ERDA officials, was based on the current status of MHD technology development at that time and is still valid today.

No specific mention is made in the legislative history of the fiscal year 1975 MHD appropriation that the CDIF be located in Montana. However, ERDA program managers believed it was the Congress's general preference that the CDIF be located near the Montana College of Mineral Science and Technology in Butte, Montana. Accordingly, ERDA did not make an analysis of constructing the CDIF in any place other than a 25-mile radius of Butte, Montana. On October 3, 1975, a site selection panel was formally appointed, and on December 10, 1975, a 93-acre site 5 miles south of

Butte was selected. The site selection panel was directed not to consider locations other than the Butte area. Thus, ERDA did not make any analysis of the economical or environmental advantages or disadvantages to locating the CDIF in Montana or in States other than Montana.

The site selection panel report states that the Butte area was selected so that the

> " * * * CDIF could utilize the resources of the Montana College of Mineral Science and Technology and other units of the Montana University system as well as serve to bolster the severely depressed economy of the Butte area."

The legislative history of the fiscal year 1976 MHD appropriation authorization and recent congressional approval of an ERDA $20-million reprograming request to expedite the design and construction of the CDIF made it clear, however, it was the Congress's intent that the CDIF be located in Montana.

The legislative history of the fiscal year 1976 MHD appropriation authorization (section 101(a)(1)(L) of Public Law 94-187, December 31, 1975) includes the following statement in the conference committee report:

> "For the Component Development category $3.8 million will be used to accelerate the effort on the Component Development and Integration Facility. The funds will be expended on both the basic facility and on additional effort on test equipment to be utilized in that facility." H.R. Conf. Rept. No. 94-696, 44 (1975).

In addition, the following exchange between Senators Mansfield and Jackson took place when the conference report was presented on the Senate floor:

> "(MR. MANSFIELD.) I ask the chairman of the conferees, with regard to CDIF--that is the Component Development Integration Facility--where is that to be established?"
>
> "MR. JACKSON. In Montana specifically in Butte I believe. The majority of the testing work, as I understand it, on MHD, will be done in Montana."

"MR. MANSFIELD. Does the chairman agree with the two Senators from Montana that a very sizable portion of these funds will be used by the Montana Energy Research Institute, the Montana College of Mineral Sciences and Technology, and the Montana State University for the purpose of developing an MHD program primarily centered around Montana Tech in Butte and Montana State University?"

"MR. JACKSON. The Senator is correct, and I should like, as chairman of the Interior Subcommittee handling this aspect of the bill to say that that is our legislative intent, based on our understanding. I want to make it clear that it is part of the legislative history of this conference report."

"MR. MANSFIELD. Is it the intent of the committee and the Congress as a whole that construction on the component development integration facility should start no later than next spring in Montana?"

"MR. JACKSON. That is correct; consistent, naturally, with ERDA's plans. But our clear understanding is that next spring should be initiation of construction." Cong. Rec., December 9, 1975, (daily ed.) S. 21460.

As recent evidence of congressional intent that construction of the CDIF proceed in Montana, the Congress approved, effective April 14, 1976, an ERDA request to reprogram $20 million from other ERDA programs to the MHD program to accelerate the design and construction of the CDIF in Montana.

CONCLUSIONS

Our review of pertinent legislation authorizing MHD development and supporting legislative history clearly shows that the Congress intended that ERDA build two facilities--the CDIF and ETF--in the State of Montana. Because of this congressional mandate, ERDA has not made any analysis to determine whether it would be more advantageous to build either of these facilities in a State other than Montana.