REPORT BY THE

Comptroller General

OF THE UNITED STATES

The Department Of Energy's Water-Cooled Breeder Program-- Should It Continue?

GAO addressed three questions about the water-cooled breeder program:

--Should it continue? GAO believes current reactor operations should be terminated in January 1982 to answer the basic question: Does the reactor breed? The Department of Energy's position is that given the program's developmental nature, it should be continued as long as possible to obtain "maximum technical data" on fuel efficiency.

--Is the management effective? On a day-to-day basis it is; however, GAO identified several areas where long-term planning could be improved.

--What issues need to be resolved before the technology can be commercialized? GAO identified a number of issues, all revolving around the need to develop the complete reactor fuel cycle and many of which must be resolved to commercialize any breeder reactor concept.

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

B-202528

The Honorable Marilyn L. Bouguard
Chairman, Subcommittee on Energy
Research and Production
Committee on Science and Technology
House of Representatives

Dear Madam Chairman:

On May 2, 1980, the former Subcommittee Chairman requested that we review the Department of Energy's (DOE) water-cooled breeder program. This program, which began in 1965, is aimed at proving that existing types of nuclear powerplants—called water-cooled reactors—can produce more fuel than they consume. Through the end of fiscal year 1981, the Federal Government will have spent $518 million to develop this breeder concept.

This report addresses two major issues. First, it explains why GAO believes that DOE should discontinue its current program plans and instead, concentrate on the major focus of the program—demonstrating the reactor's breeding potential. Second, the report discusses factors the Department of Energy needs to consider when deciding whether the water-cooled breeder concept should be developed further.

As discussed with your office, we plan to send copies of this report to interested parties and make copies available to others upon request.

Sincerely yours,

Milton J. Socolar

Acting Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT TO THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

THE DEPARTMENT OF ENERGY'S WATER-COOLED BREEDER PROGRAM--SHOULD IT CONTINUE?

D I G E S T

BACKGROUND

From the beginning of the Nation's nuclear power program, there has been general agreement that the Nation's supplies of economically recoverable uranium are limited and any long-term plans for nuclear power would require more efficient uranium resource use. Because current generation nuclear powerplants, commonly referred to as water-cooled reactors, make relatively inefficient use of their uranium fuel, the Department of Energy (DOE) assigned a high priority to developing a breeder reactor--a reactor which produces more usable nuclear fuel than it consumes. Currently, DOE has two breeder technologies under development: the liquid metal fast breeder and the water-cooled breeder. Of these, the liquid metal fast breeder reactor has always been accorded higher development priority.

Among the reasons for according the liquid metal fast breeder reactor higher development priority was its superior breeding potential. While the water-cooled breeder is only expected to be a self-sustaining reactor--producing enough fuel to refuel itself after covering losses incurred in the recycle process--the liquid metal fast breeder can refuel itself and also provide fuel for additional reactors. In addition, the spent fuel from existing water-cooled reactors can provide the initial fuel for the liquid metal fast breeder reactor, whereas special reactors--called prebreeders --are necessary to produce the initial fuel for the water-cooled breeder reactor.

Although DOE recognized that the water-cooled breeder did not have the breeding potential of the liquid metal fast breeder, the water-cooled breeder nonetheless offered the potential of using fuel more efficiently than existing water-cooled reactors. Furthermore, this concept looked promising because it could "build on" established water-cooled reactor technology and could potentially be marketed by the existing industrial infrastructure. Further, the technology offers the possibility of using another plentiful energy source--thorium. DOE continued to fund and support the water-cooled breeder program. From 1965 through fiscal year 1981, the Federal Government has spent about $518 million to develop the water-cooled breeder reactor concept. When the program originated in 1965, the primary objective was to prove by 1978 that this reactor would breed. (See p. 1.)

FINDINGS

The Chairman, Energy Research and Production Subcommittee, House Science and Technology Committee, asked GAO to address several questions about this program.

--Should the water-cooled breeder program continue? The short answer is yes--until January 1982; nonetheless, GAO believes that DOE should move forward now to prove that the watercooled breeder does breed rather than pursuing other, secondary objectives which will substantially add to the cost and time required to complete the project. (See pp. 8 to 12.)

--How effective is the program's management? The short answer is that day-to-day management control is effective but changes could be made to DOE's long-term planning efforts. GAO believes that (1) DOE needs to develop long-term cost and schedule estimates to allow for more accountability for achieving critical steps in the development process (See pp. 13 to 15.) and (2)

as soon as the proof-of-breeding experiment is complete, DOE should transfer responsibility for the program to the division responsible for developing other commercial reactor systems. (See pp. 15 to 17.)

--What issues would have to be resolved before the water-cooled breeder could become commercially viable? There is no short answer, but GAO identified several technical and institutional problems that would have to be resolved before deciding on this reactor's role in the Nation's energy future. GAO recognizes some of these problems are generic to developing and commercializing any breeder reactor. (See pp. 17 to 23.)

The following sections discuss the results of GAO's review in more detail.

DOE SHOULD PROVE BREEDING IN THE WATER-COOLED BREEDER

The primary goal of the water-cooled breeder program is, and always has been, to confirm that the water-cooled breeder reactor breeds using the thorium/uranium fuel cycle. Until and unless DOE confirms that the water-cooled reactor does breed, further decisions on the future development of the reactor cannot be made. If it does breed, and if nuclear power is determined to be a long-term energy source, the breeder may have an important role in meeting future energy needs. If it does not breed, however, it's role in the Nation's energy future is speculative and would require a new evaluative effort. Thus, in GAO's view, this confirmation should be made as soon as possible.

Originally, breeding performance was to be determined as quickly as possible. This was to be achieved by burning fuel in a DOE-owned reactor for 3 or 4 years, then removing and examining the fuel. Over the years, however, DOE has decided to delay the proof-of-breeding effort and extend reactor operations

to gather additional information on the fuel. Accordingly, DOE revised the program's operating objectives to emphasize maximum utilization of the reactor and the fuel. This emphasis is based on DOE's belief that this program is a developmental effort and should be continued as long as useful technical information can be obtained. DOE believes this approach makes sense because the reactor core is capable of longer operation and thus provides an excellent opportunity to more fully demonstrate the technology and to provide important technical information.

Extending reactor operating life changes the time frame for proving breeding and increases program cost. Specifically, DOE's decisions to extend reactor operation has added slightly more than 4 years to the program at an additional cost of about $200 million. Further, information on the reactor's breeding potential will not be available before 1989--11 years after originally scheduled. In addition, DOE is now evaluating actions which would delay the proof-of-breeding until 1990 at additional costs. (See pp. 8 to 11.)

GAO asked DOE several times to provide specific data on the value of continuing reactor operation to obtain additional information on fuel behavior. DOE has not analyzed the costs and benefits of continuing reactor operation versus confirming breeding potential as quickly as possible. Further, DOE has not evaluated other options available to gather additional information on fuel behavior. (See p. 10.)

In GAO's view, determining the reactor's breeding potential as quickly as possible should be the most important goal of the program. Until breeding is confirmed, there is no sure way of ascertaining U.S. utility interest in the water-cooled breeder.

GAO's review showed that, to date, the nuclear industry has expressed little interest in the concept. However, if and when its

breeding ability is confirmed, nuclear utilities may take a more active interest in developing it. Thus, the nuclear industry needs information on the water-cooled breeder's breeding capability as soon as possible so that it can be compared to other breeder alternatives and a decision on its future can be made. (See pp. 11 to 12.)

DOE also needs information on the reactor's breeding capability to compare this concept with other competing, advanced nuclear technologies. Such a comparison is particularly important given (1) the limited availability of Federal funds for competing energy research and development projects and (2) the limited private funds of U.S. utilities for developing commercial energy technologies. (See p. 12.)

MANAGING THE WATER-COOLED BREEDER PROGRAM: PAST AND FUTURE CONCERNS

With regard to the Subcommittee's questions about the effectiveness of the program's management, GAO found that on a day-to-day basis DOE's management control system is effective but noted two areas where changes should be made to improve the program for now and in the future.

DOE's water-cooled breeder program plans lack specifics

Specifically, GAO believes that DOE needs to develop long-term cost and schedule estimates to allow for more accountability for achieving critical steps in the development process. Creating such a system will in GAO's view not only help improve what is essentially an effective day-to-day management system, but will also provide a good basis for managing further development of this technology and provide Congress with a better basis for carrying out its oversight responsibilities. (See pp. 13 to 15.)

Responsibility for the program management should change following the proof-of-breeding experiment

In addition, as soon as the proof-of-breeding experiment is complete, GAO believes responsibility for the program should be transferred to the DOE division responsible for developing other commercial breeder reactor systems. This will better enable DOE to judge the merits of the water-cooled breeder versus other nuclear technologies in allocating scarce Federal energy research and development funds. (See pp. 15 to 17.)

INSTITUTIONAL AND TECHNICAL ISSUES AFFECTING THE FUTURE ROLE OF THE WATER-COOLED BREEDER REACTOR

In addressing the Subcommittee's last concern, GAO identified the following institutional and technical factors that DOE must consider when deciding on the water-cooled breeder reactor's future development and commercial future. GAO recognizes that many of these issues are problems generic to developing and commercializing any breeder reactor.

--The future role of nuclear power in meeting the Nation's energy needs; (See pp. 17 to 18.)

--The potential role of the water-cooled breeder versus other breeder technologies; (See pp. 18 to 20.)

--The apparent lack of substantial electric utility and nuclear vendor interest; (See pp. 20 to 22.)

--The need to develop a thorium fuel cycle capability; and (See p. 22.)

--The need for nuclear fuel reprocessing. (See pp. 22 to 23.)

CONCLUSIONS

Clearly, if nuclear power is to play a long-term role in meeting the Nation's energy needs, a breeder reactor must be developed and commercialized. The water-cooled breeder reactor provides one breeder option. However, a major question regarding this technology remains unanswered--does the water-cooled breeder use its energy resources more efficiently than current water-cooled reactors or specifically, does the water-cooled breeder actually breed? Before a decision can be made on the next step in developing this technology or on its commercial usefulness, this question must be answered.

In GAO's view, demonstrating the reactor's breeding potential as quickly as possible is still the program's primary and most important goal. DOE and the nuclear industry need this information to be able to compare this technology to other options and to make a decision on its further development and/or commercialization. Furthermore, DOE plans to obtain additional fuel behavior information at a cost of about $200 million without an adequate justification of its potential worth. GAO believes a better approach would be to determine the breeding potential of the technology as soon as possible.

Should DOE and the nuclear industry decide that the water-cooled breeder concept warrants further development, DOE should (1) make several changes to improve both current and future program management and (2) resolve several unanswered technical and institutional questions affecting its commercial potential. Specifically, DOE needs to develop and use a more detailed cost and schedule control system and as soon as the proof-of-breeding experiment is complete, transfer program responsibility to the DOE division developing other commercial nuclear reactor fuel systems. Also, DOE must consider

various institutional and technical issues affecting the water-cooled breeder when determining whether to proceed with this concept.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

GAO recommends the Secretary of Energy:

--Discontinue reactor operation at Shippingport by January 1982 and initiate the proof-of-breeding experiment at that time.

--Establish fixed milestones and cost projections for all major activities so that (1) the performance of the program can be better measured (2) accountability over achieving critical steps in the development process can be better established, and (3) congressional oversight over program progress can be improved.

--Transfer responsibility for any further development of the water-cooled breeder to the Deputy Assistant Secretary for Nuclear Reactor Programs if such development is warranted.

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On February 27, 1981--the same day DOE commented on this report--the Division of Naval Reactors informed the Division of Nuclear Reactor Programs of its plan to again extend operation of the Shippingport reactor until 1985. The draft report, as sent to DOE for comment, was based on DOE's initial decision to extend reactor operations until January 1982. DOE's comments to GAO did not mention that additional extensions to reactor operation beyond January 1982 were imminent, although studies had been underway on the possibility of a 2-year extension. The report has been changed to reflect the potential additional costs that may be incurred as a result of this decision.

AGENCY COMMENTS

DOE provided written comments on GAO's draft report. The Department disagreed with GAO's conclusion that DOE should pursue the primary goal of the program--demonstrating the reactor's breeding potential--as quickly as possible. DOE emphasized that its basic position of continuing the program as now planned provides a unique opportunity to develop an improved understanding of the physics and engineering aspects of the thorium/uranium fuel while still allowing for breeding to eventually be determined. DOE said the cost of this approach is justified not only on that basis but also because it provides important technical information for more efficient use of nuclear fuel resources in light water reactors.

DOE also disagreed about the value of establishing long-term milestones and cost projections for the program, and said that the report conveyed the impression of a strong bias against the water-cooled breeder in relation to the liquid metal fast breeder reactor.

In evaluating the Department's comments, GAO maintained its position that the most important objective of the program is to determine as quickly as possible whether the water-cooled reactor does breed. Until this is done, the future development of that breeder is questionable. In addition, GAO pointed out that other perhaps less costly options exist to obtain information on fuel behavior. GAO also restated the need to develop long-term milestones and cost projections for use by senior agency management in measuring program progress, and by the Congress in making budgetary decisions. Finally, GAO pointed out that the discussion of the water-cooled breeder relative to the liquid metal fast breeder reactor is based on DOE's own documents and studies of the two technologies.

A summary of DOE's comments and GAO's evaluation of them is included in chapter 4 of the report. The complete text of DOE's comments is included in appendix I.

Contents

ABBREVIATIONS

DOE	Department of Energy
GAO	General Accounting Office

CHAPTER 1

INTRODUCTION

Today, 10 percent of this country's electricity is generated by nuclear power. Seventy-three commercially-owned nuclear powerplants are currently licensed to operate with another 103 plants under construction or planned. All but one of these current generation of nuclear powerplants are water-cooled reactors, which, unfortunately make relatively inefficient use--1 or 2 percent--of the energy potential in the ore used to fuel them.

From the beginning of the Nation's nuclear power program, the Federal Government and the nuclear industry recognized that the Nation's supplies of economically recoverable uranium are limited, and long-term plans for nuclear power would require more efficient uranium resource use. Developing a breeder reactor--a reactor which produces more useable nuclear fuel than it consumes--could accomplish this objective. Consequently, several breeder reactor concepts have been studied, including (1) the molten salt breeder, (2) the gas-cooled breeder, (3) the liquid metal fast breeder, and (4) the water-cooled breeder. Over the course of development, however, the Department of Energy (DOE) has terminated its programs for the first two breeder concepts.

Of the two remaining breeder concepts being researched and funded by DOE, the liquid metal fast breeder reactor has been accorded higher reactor development priority. This reactor was selected because of (1) its predicted performance, (2) more efficient use of the energy potential in uranium, (3) existing industrial support, (4) technological experience, and (5) its proven feasibility. DOE's research and development effort for the liquid metal fast breeder reactor has been extensive and, to date, has cost the government about $5 billion.

Although not receiving the emphasis accorded the liquid metal fast breeder reactor, the water-cooled breeder also continued to receive Federal funding and support. From 1965 to fiscal year 1981, the Federal Government spent about $518 million to develop the water-cooled breeder concept.

THE ORIGIN OF THE WATER-COOLED BREEDER REACTOR

In the early 1960s, the former Atomic Energy Commission 1/ worked on a concept to develop a modified water-cooled nuclear reactor that could produce additional fuel--or breed --as it operates. This concept looked promising because it (1) could "build on" established water-cooled reactor technology and (2) offered the potential of using fuel more efficiently. This early research work led to the establishment of the light water breeder reactor project in December 1965. Today, this project is called the water-cooled breeder program.

According to DOE, perhaps the most important reason for pursuing the water-cooled breeder was its ability to take advantage of the already existing, fully-commercialized water-cooled reactor technology. The water-cooled breeder can use established water-cooled reactor components so only the fuel needs to be developed for the powerplant. In addition, the water-cooled breeder has the potential of being marketed by current nuclear reactor vendors as a replacement for, or complement to, existing reactors.

THE WATER-COOLED BREEDER PROGRAM'S PURPOSE AND MANAGEMENT

The water-cooled breeder reactor program is divided into three major subprograms:

--the Shippingport Atomic Power Station subprogram involves operating and testing a water-cooled breeder reactor;

--the Light Water Breeder Reactor subprogram for developing, designing, fabricating, and testing water-cooled breeder fuel for the station; and

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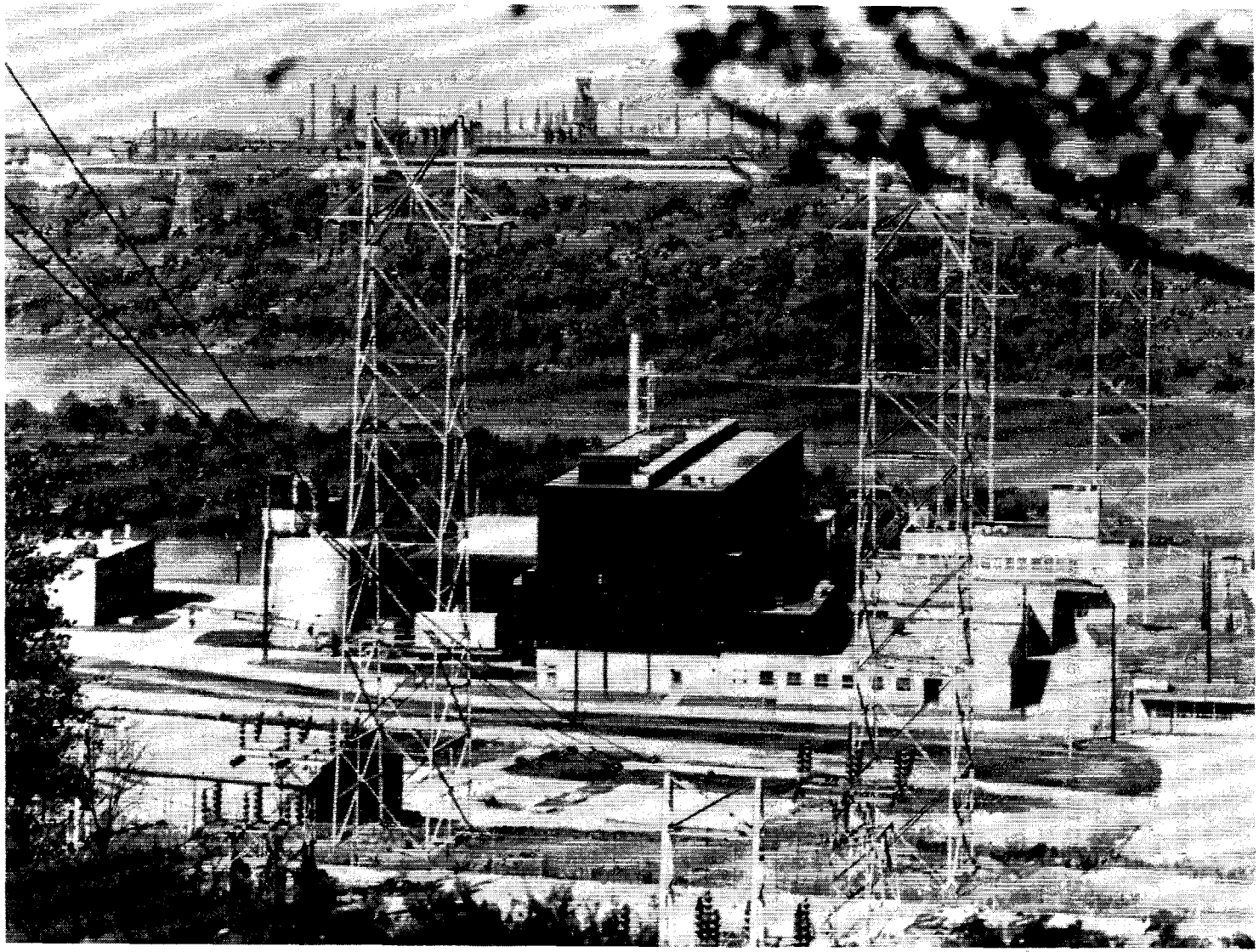
1/The Energy Reorganization Act of 1974 (Public Law 93-438) abolished the Atomic Energy Commission and transferred responsibility for certain development functions to the Energy Research and Development Administration. Effective October 1, 1977, these functions were transferred to the Department of Energy.

--the Advanced Water Breeder Applications subprogram for developing and disseminating technical information to the nuclear industry on the concept.

All three subprograms are managed by DOE's Division of Naval Reactors. Under that management, the water-cooled breeder program is being carried out at the Shippingport Atomic Power Station, located 25 miles northwest of Pittsburgh, Pennsylvania, and at two Government-owned laboratories which work exclusively on the Division's programs--Bettis Atomic Power Laboratory, near Pittsburgh, Pennsylvania, and Knolls Atomic Power Laboratory in Schnectedy, New York. These laboratories are operated under contract by the Westinghouse Electric Corporation and the General Electric Company, respectively.

The Bettis Laboratory had the principal role in designing, developing, and manufacturing the reactor core for the water-cooled breeder. In 1977, the breeder core was placed in the Shippingport Atomic Power Station, pictured on page 4, and DOE began testing the fuel through operation of the reactor. After several years of operation, the fuel is to be removed from the reactor to determine the water-cooled breeder reactor's breeding potential.



SHIPPINGPORT ATOMIC POWER STATION.

According to DOE officials, current data from Shippingport operations continue to suggest its potential for breeding. Breeding, however, can only be proven by operating the reactor for a practical lifetime and then removing the fuel from the plant and examining it. This examination involves comparing the final amount of fissile material 1/ in the fuel to the initial amount of fissile material in the fuel before burning. If the reactor contains enough fissile material to fuel a subsequent reactor, after covering losses incurred in the recycle process, the breeding potential of the water-cooled breeder will have been demonstrated.

OBJECTIVES, SCOPE, AND METHODOLOGY

On May 2, 1980, the Chairman, Energy Research and Production Subcommittee, House Science and Technology Committee, asked us to review DOE's water-cooled breeder program. (See appendix II.) Our objectives in conducting this review were to answer the following questions:

--Should the water-cooled breeder program continue?

--How effective is the program's management?

--What issues would have to be resolved before the water-cooled breeder could become commercially viable?

To answer these questions, we contacted DOE and the Nuclear Regulatory Commission because DOE operates the program and the Commission is responsible for determining the licensability and safety of commercial nuclear technologies. Within DOE, we conducted our review at two offices: the Division of Naval Reactors which has the overall management responsibility for the program, and the Division of Nuclear Power Development which is responsible for developing the associated thorium fuel cycle as well as other breeder reactor technologies. We also toured the Shippingport Atomic Power Station and the Bettis Atomic Power Laboratory.

We reviewed numerous reports on the water-cooled breeder to determine the program's purpose, objectives, and problems. We also reviewed these documents to determine nuclear industry

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1/Fissile material is that which is capable of sustaining criticality while being burned in a nuclear reactor.

interest in the water-cooled breeder technology. A bibliography of reports pertinent to the water-cooled breeder reactor program is included as appendix III.

In addition to reviewing technical documents on the water-cooled breeder, we examined DOE's Division of Naval Reactors' annual program plans, appropriation hearings, and budget requests to help determine whether the program should continue and the effectiveness of the program management. We discussed these documents with the two DOE divisions involved.

In determining what technical issues remained to be resolved before the water-cooled breeder could be commercially viable, we relied heavily on the technical documents referred to above. Although we identified several technical issues that must be resolved, we did not evaluate in detail or compare any specific technical issues such as its safety or economics with other competing nuclear technologies. A comparison of this nature will be more valid after a decision is made on whether to further develop and demonstrate the water-cooled breeder concept.

We recognized the potential limitations of gathering only the views of Federal agencies and therefore, we developed a questionnaire (see appendix IV) which was sent to:

--five companies involved now or in the past with the construction of nuclear reactor systems;

--six electric utility industry groups; and

--the 65 largest electric utilities in the United States in terms of electric generating capacity. 1/

The questionnaire primarily requested the recipient's views on their interest in the water-cooled breeder concept and technical issues they believed should be resolved. The questionnaire was sent to organizations who will primarily be involved in determining whether to have a nuclear industry based on water-cooled breeder technology. A listing of all questionnaire recipients is included as appendix V.

1/These 65 utilities had 72 percent of the Nation's generating capacity as of June 1980.

We sent a total of 76 questionnaires. All the reactor vendors and electric utility organizations responded, but four utilities chose not to participate. In addition, six utilities simply responded that they had no knowledge of the technology. Of the 66 respondents providing answers, not all answered every part of each question.

At the start of our review, we contacted DOE's Office of Inspector General to obtain any internal documents pertinent to the subject. We found that this office had not reviewed the water-cooled breeder reactor program.

DOE commented on our draft report on February 27, 1981. On this same date DOE's Division of Naval Reactors notified the Division of Nuclear Reactor Programs that a decision had been made to operate the Shippingport reactor 3 years beyond the currently authorized date of January 1982. Our draft report was based on the authorized operation date and speculation that approval might be granted for an additional 2 years of operation. The report reflects our estimates of the potential costs which may be incurred as a result of the decision to extend the program by 3 rather than 2 years.

CHAPTER 2

DOE SHOULD PROVE BREEDING IN THE WATER-COOLED BREEDER

The most important goal of the water-cooled breeder program is, and has always been, to confirm whether breeding of additional fuel is possible in a water-cooled reactor using the thorium/uranium fuel cycle. This confirmation is important because until the water-cooled breeder's breeding capability is determined, it is not known to what extent this technology can improve uranium resource use. In fact, if it does not breed, it is questionable whether the utility industry will be interested in further development.

Until recently, this goal was to be pursued, and achieved, as quickly as possible. Recently, however, DOE decided to pursue secondary objectives that will not only delay achievement of this primary goal, but will also extend completion of the program and add to its overall costs. Furthermore, DOE is considering additional actions that could further delay confirmation of breeding. In our view, DOE should not continue to delay confirmation of breeding, but should pursue this important objective as soon as possible.

DOE'S DECISION TO EXTEND REACTOR OPERATION DELAYS PROOF-OF-BREEDING

Instead of quickly confirming the breeding potential of water-cooled reactors, DOE has now chosen a course that, while still allowing for breeding to eventually be determined, is intended to defer this determination indefinitely to provide additional information on fuel behavior. In our view, determining the reactor's breeding potential is the most important goal of the program and should be pursued as soon as possible. If the reactor does not breed, the information on fuel behavior may be of questionable value since it is uncertain whether the utility industry will be interested in possible commercial development.

DOE originally designed the water-cooled breeder reactor project to operate a total of 18,000 hours at full power, or about 3 to 4 years, at which time the reactor fuel would reach the end of its then expected lifetime. DOE believed that when the reactor operated for 18,000 hours, it would be possible to prove that breeding had occurred. In August 1979--one year before the reactor reached 18,000 hours--DOE decided that the reactor should operate longer. Although DOE still believed

that breeding could be determined at 18,000 hours, it now believed that the reactor could, and should, operate longer than its expected lifetime. DOE's rationale for this decision was that continued reactor operation would provide a unique opportunity to develop an improved understanding of the physics and engineering aspects of the thorium/uranium fuel. DOE told us that to obtain the same amount of information on this fuel system through any other form of testing could take many years, and would be prohibitively expensive.

In justifying its decision to extend reactor operation beyond its original anticipated lifetime, DOE revised the program's operating objectives to emphasize maximizing utilization of both the reactor and the fuel while still allowing for breeding to eventually be determined. A comparison of the original and revised objectives follows:

Objectives for the Light Water Breeder Reactor Subprogram

Original	Revised
1. Prove that breeding can be achieved in a water-cooled reactor using thorium/uranium fuel.	1. Demonstrate that breeding can be achieved in a water-cooled reactor for the "maximum practical lifetime."
2. Confirm a practical way to obtain energy from thorium.	2. Maximize fuel utilization.
3. Show that a water-cooled breeder reactor that uses thorium fuel can be installed in a pressurized water nuclear powerplant using the same type of equipment as used in commercial reactors.	3. Obtain operational experience with thorium fuels and fuel support equipment to the maximum extent practical consistent with (1) above.

DOE requested Bettis Laboratory to submit a plan for continuing reactor operation beyond the planned 18,000 hours. In early 1980, Bettis laboratory submitted a plan that called for running the reactor for a minimum of 28,000 hours. DOE and Bettis officials recognized that continued reactor operation to 28,000 hours at its present power level and temperature could damage the fuel rods. Therefore, to sustain

continued operations without damaging the fuel, the revised plan called for reductions in power, pressure, and temperature in future reactor operations.

DOE subsequently approved this recommendation but only to 24,000 hours. As a consequence of this decision, preparations for defueling and examination of the expended fuel were delayed to coincide with a later shutdown date--January 1982. On February 27, 1981,--the same day DOE commented on this report--the Division of Naval Reactors informed the Division of Nuclear Reactor Programs of its plan to operate the Shippingport reactor until early 1985--a further 3-year extension of reactor operating time. DOE is also evaluating the possibility of operating the reactor an additional year--or until early 1986.

During our review, we asked DOE several times to provide specific data on the value of continuing reactor operation to obtain additional information on fuel behavior. DOE did not do an analysis prior to either the 1980 or the recent decision of the costs and benefits of continuing reactor operation to acquire additional fuel information versus proving breeding as quickly as possible. Specifically, DOE could not provide us any information on why the nuclear industry would need the additional information now, why the information could not be developed later by different options, or a cost comparison of performing the tests now as opposed to later.

We believe that additional information on fuel behavior can be obtained in one of two other ways--a test reactor or in a later commercial demonstration reactor. The use of a test reactor for this purpose is feasible but would take longer than continuing present reactor operation. However, this method would not delay the proof-of-breeding determination, may cost less, and could be stopped if the reactor does not breed. The fuel can also be further tested in a subsequent larger demonstration reactor if a decision is made to further develop the technology. We believe that these factors support our contention that proof-of-breeding should not be delayed to obtain this additional information.

CHANGES IN OPERATING OBJECTIVES EXTEND THE PROGRAM

The water-cooled breeder program was originally scheduled to be completed--and the information on breeding potential

available to industry--by 1978. DOE's decision to seek additional information has extended the program so that now, if DOE's current plans are pursued, this information cannot possibly be available until 1989, 11 years after its original completion date.

Each additional year the program is extended requires additional annual funds for each of the program's three subprograms. DOE's initial decision in 1980 to extend reactor operation will increase program cost about $50 million --$6 million 1/ for continuing the operation of Shippingport, $24 million for continuing the light water breeder reactor subprogram and $20 million for the advanced water breeder applications subprogram.

DOE's decision to operate the reactor another 3 years will add an additional program cost of $150 million. In addition, a DOE official told us that this 3-year delay will result in a $5-6 million increase in costs to Argonne National Laboratory which will verify the results of the proof-of-breeding experiment. These costs are not included in the water-cooled breeder's budget but are in DOE's budget. Thus, DOE plans to spend at least $200 million to obtain additional information on fuel without an adequate justification of its potential worth.

THE NUCLEAR INDUSTRY NEEDS INFORMATION ON THE REACTOR'S BREEDING POTENTIAL FIRST

The nuclear industry will ultimately be the purchasers of the water-cooled breeder, should it ever be commercialized. Therefore, the nuclear industry has an important role in determining the reactor's commercial potential, and whether a program should be continued in DOE to develop the necessary technology. All of these decisions are dependent upon whether the water-cooled breeder reactor breeds.

Until breeding is confirmed, there is no sure way of ascertaining U.S. utility interest. To date, little interest has been expressed by the utility industry for this concept. We surveyed 76 utilities, utility associations, and nuclear manufacturers and did not find an overwhelming interest in pursuing the water-cooled breeder. Also, DOE officials

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1/This cost figure for operating the Shippingport reactor represents the cost after deducting revenues for operation paid by Duquesne Light Company.

told us that to their knowledge, no group in the industry--utility, vendor, or architect-engineer--has stated a desire to develop the water-cooled breeder.

DOE officials further stated, however, that vendors and utilities should not be expected to show substantial interest in applying water-cooled breeder technology until the information is available on whether the reactor actually breeds. When the technical results for the Shippingport tests are known, industry can then determine how it wishes to use the technology.

This view was further supported in a recent DOE report --"the Nonproliferation Alternative Systems Assessment"--that compared alternative nuclear concepts. This report recognized the DOE research and development effort on the water-cooled breeder technology and highlighted the objective of the program; i.e. to confirm that breeding can be achieved and then developing and disseminating technical information to industry to assist in evaluating the breeder's commercial potential. Its recommendation for the water-cooled breeder concept was that the program should continue to meet this objective so its future course could be decided after considering its results.

Considering these views, it seems clear that the most important information on the water-cooled breeder concept required by the nuclear industry is a determination of its breeding potential. Only after the utilities receive and review this information can they make a decision on the water-cooled breeder reactor's further development and possible commercial future. Furthermore, the nuclear industry and DOE will need this information to compare this concept with other advanced nuclear breeder technologies being developed for commercial application, especially the liquid metal fast breeder reactor. Such a comparison is particularly important given (1) the limited availability of Federal funds for competing energy research and development projects and (2) the limited private funds of U.S. utilities for developing commercial energy technologies.

CHAPTER 3

MANAGING THE WATER-COOLED BREEDER PROGRAM: PAST AND FUTURE CONCERNS

The previous chapter discussed our belief that the water-cooled breeder reactor program should continue but that DOE should have as its overriding objective determining the reactor's breeding capability as soon as possible. While the Subcommittee was principally interested in addressing this issue, it also asked us to identify other issues that must be considered after breeding potential is proven and before this technology can proceed to subsequent steps in the research, development, and commercialization process. Specifically, the Subcommittee wanted to know:

--What can be learned from how the program has been managed in the past as a basis for managing the program in the future and what changes, if any, should be made to the management structure?

--What other technical and institutional problems must be considered and resolved before the water-cooled breeder reactor can be commercialized? In answering this question, we found that many of these problems are generic to developing and commercializing any breeder reactor.

The following sections discuss the results of our work in detail.

DOE'S WATER-COOLED BREEDER PROGRAM PLANS LACK SPECIFICS

DOE's Division of Naval Reactors maintains central technical control for this breeder program whereby it provides the management and technical direction on all aspects of the program from headquarters in Washington. This includes directing all technical work, establishing priorities, and reviewing and approving all technical reports. On a day-to-day basis, this management approach is effective. However, we believe that DOE's long-term planning efforts could be improved.

DOE's research and development effort on the water-cooled breeder has exceeded initial estimates in time and money. DOE has not established long-term milestones and cost projections for completing the program. In our view, such milestones and projections can improve program accountability

and oversight. Further, these projections would provide Congress an adequate opportunity to monitor the pace of the program as part of its budgetary oversight responsibilities.

DOE originally estimated in congressional appropriation hearings that the water-cooled breeder fuel could be installed in the Shippingport plant to begin operation in 1973. The fuel was not installed and in operation, however, until December 1977. In addition, DOE originally planned on disseminating information to industry on the reactor's breeding potential by 1978. Currently, DOE documents state that this is to be completed in 1989. This date could be changed again should DOE decide to continue operating the reactor another year. DOE officials attribute the first four-year delay to unexpected budgetary constraints, technological problems, high inflation rates, and the need to upgrade the Shippingport Atomic Power Station to meet requirements that did not exist when the first projections were made. The remainder of the time it attributes to program decisions to operate the core longer.

The program costs have also surpassed original projections. DOE originally estimated that the total project would cost $91.5 million. To date, the program has been appropriated $518 million with current plans to continue the program about 8 more years. The program's total expected cost is now about $968 million. Thus, since 1965, the expected costs of the program have increased by about $876 million, more than a nine-fold increase.

Based on our comparison of the two estimates, $169 million of the $876 million increase, or 19 percent, is due to inflation through fiscal year 1978. Program delays at the startup of the program, when general research and development work on the water-cooled breeder concept was being performed, accounted for another $21 million. Thus, the remaining $686 million increase (78 percent) is likely due to changes in the program, technical problems, and not completing project segments on schedule.

We recognize that cost and time overruns are inherent in any large research and development effort and are not unique to the water-cooled breeder program. Nonetheless, we do not believe that this weakens the need for preparing program plans with specific time frames and cost projections. The value of such a plan has long been acknowledged by DOE and other government agencies involved in long-term development projects and has been routinely used in programs such as nuclear fusion and the moon-shot efforts of the 1960s.

DOE, however, did not prepare any program plans until 1976--11 years after the start of the program. Also, program plans prepared by DOE since 1976 do not contain any long-term milestone and cost projections. In fact, many of the program's major efforts do not have any scheduled completion dates. Furthermore, many of the short-term milestones are openended; i.e., they do not commit to specific time frames or costs and are subject to change. Each short-term milestone projection on DOE's charts is footnoted with the following statement: "These are the earliest possible dates. The dates will be delayed if the reactor operates longer than shown."

Water-cooled breeder reactor program officials do not believe long-term milestones and cost projections are needed. These officials believe that the evolving nature of a research and development effort must be borne in mind when evaluating cost and schedule projections because each step in a development effort can result in following a new path to completion. Therefore, they do not believe that projection reports are of any value for controlling their work.

We do not want to infer that the existence or nonexistence of such reports will either cause major program delays or cost overruns. However, we believe that senior agency officials, other administrative officials, and congressional officials need these reports--more so than program officials--to chart program progress and accomplishments, and to compare such progress and accomplishments with other programs so that they are in a better position to make important budgeting decisions. Without such a "roadmap" it is difficult, at best, to measure progress in reaching program goals. Furthermore, accountability by program managers is strengthened for completing the project within certain timeframes and total costs; and thus, the timing and costs of the project, as well as project objectives, cannot be changed without adequate justification.

RESPONSIBILITY FOR THE PROGRAM MANAGEMENT SHOULD CHANGE FOLLOWING THE PROOF-OF-BREEDING EXPERIMENT

If the water-cooled breeder does, in fact, breed and the nuclear industry is interested in further development of the technology, DOE would most likely need to establish a program to demonstrate its commercial potential. When, and if, this occurs, DOE must address several issues necessary for the water-cooled breeder to become commercially viable: (1) the development of a thorium fuel cycle capability, (2) obtaining nuclear industry involvement in

the program, and (3) the future economics of the concept. We believe that these and all other future efforts on the water-cooled breeder, as well as all breeder concepts, should be directed by one group in DOE.

Within DOE, all civilian-oriented nuclear reactor development programs, except the water-cooled breeder program, are under the purview of the Deputy Assistant Secretary for Nuclear Reactor Programs. These development efforts include the current generation water-cooled reactors, advanced converter reactors, the liquid metal fast breeder reactor, and their respective fuel cycles.

The water-cooled breeder reactor program, however, was not assigned to this group, but instead, was assigned to the Deputy Assistant Secretary for Naval Reactors. This assignment was made because the Deputy Assistant Secretary for Naval Reactors had (1) extensive experience in developing water-cooled reactors for the Nation's naval ships and submarines, (2) developed and operated the first civilian nuclear powerplant, (3) determined that breeding may be feasible in a water-cooled reactor, and (4) completed preliminary work in the area. This group, however, was not assigned responsibility for developing the associated thorium fuel cycle capability--including reprocessing and refabrication. This responsibility was assigned to the civilian-oriented group. Currently, DOE has no ongoing or planned work in this area.

When, and if, a decision is made to demonstrate the water-cooled breeder reactor's commercial potential, an all-inclusive program involving reactor demonstration, fuel cycle capability development, and nuclear industry involvement must be initiated. At that time, it appears logical to transfer further development of the water-cooled breeder technology to the civilian-oriented division with both expertise and experience in commercial reactor development programs. Through its programs to develop the water-cooled reactor and the liquid metal fast breeder reactor, this group has gained experience with industry participation and the knowledge to develop the necessary fuel cycle capability. In fact, the fuel cycle development group has already determined the necessary development requirements for the water-cooled breeder fuel cycle.

Another, and perhaps more important, reason for transferring the water-cooled breeder to the Nuclear Reactors Program group is to allow it to compete with other advanced reactor technologies. This group provides research time and funding to all other nuclear reactor technologies and,

subsequently, decides which concept should receive development priority. The limited and uncertain availability of Federal funds for competing energy technologies makes a comparison of this nature essential.

Therefore, we believe future development efforts--should they be pursued--should be transferred to the Assistant Secretary for Nuclear Programs to enable a more valid comparison of the water-cooled breeder's merits with those of competing technologies. The following section describes some of the issues that should be considered in making these funding and commercialization decisions.

INSTITUTIONAL AND TECHNICAL ISSUES AFFECTING THE FUTURE ROLE OF THE WATER-COOLED BREEDER REACTOR

If DOE proves the water-cooled breeder does breed, a decision to proceed with development of this concept must be made. In making such a decision, certain factors must be considered including

--the future role of nuclear power in meeting the Nation's energy needs,

--the potential role of the water-cooled breeder,

--the apparent lack of substantial electric utility and nuclear vendor interest,

--the need to develop a thorium fuel cycle capability, and

--the need for nuclear fuel reprocessing.

We recognize that many of these issues are problems generic to developing and commercializing any breeder reactor.

The Future of Nuclear Power

In recent years, the necessity and desirability of nuclear power has been questioned. Past projections of nuclear growth have proven to be overly optimistic and in recent years the estimates have continually declined. This decline in nuclear power has coincided with the overall decline in electricity demand. Furthermore, the desirability of nuclear power has been affected by such unresolved issues as nuclear waste disposal, nuclear weapons proliferation, nuclear economics, and reactor safety.

While recognizing that decreasing electricity demand projections and concerns over the desirability of nuclear energy could adversely affect the future of nuclear energy, we believe that too much uncertainty exists to stop development of nuclear energy. Although valid concerns about nuclear power exist, unanticipated events affecting other fuels used in generating electricity could increase the demand for nuclear power.

Projections of future electricity demand are subject to considerable uncertainty. These already uncertain forecasts are further clouded by the current unstable energy situation resulting from decreasing world supplies of oil and gas. As petroleum becomes more scarce, the United States must rely more heavily on its domestic resources to meet increased electricity demand and replace lost capacity. Thus, the future need for nuclear power over the next several decades will be directly affected by the rate of development of other competing, long-term energy supply alternatives, such as geothermal, solar, fusion, and coal. If problems arise in developing the other alternatives, which is quite possible as demonstrated by several of our recent reports, 1/ nuclear energy may have to play a larger role in this Nation's future than is currently anticipated.

The Role of the Water-Cooled Breeder In View of Another Breeder Option

From the beginning of the Nation's nuclear power program, the Federal Government and the nuclear industry have recognized that the Nation's supplies of economically recoverable uranium are limited and long-term plans for

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1/"Geothermal Energy: Obstacles and Uncertainties Impede Its Widespread Use," U.S. General Accounting Office, EMD-80-36, Jan. 18, 1980.

"20-Percent Solar Energy Goal--Is There a Plan to Attain It?" U.S. General Accounting Office, EMD-80-64, Mar. 31, 1980.

"Fusion--A Possible Option for Solving Long-Term Energy Problems," U.S. General Accounting Office, EMD-79-27, Sept. 28, 1979.

"U.S. Coal Development Promises Uncertainties," U.S. General Accounting Office, EMD-77-43, Sept. 22, 1977.

the future of nuclear power have generally called for extension of these uranium supplies. Breeder reactors, which produce more fuel than they consume, would accomplish this objective. Currently, DOE has two breeder technologies under development; the liquid metal fast breeder and the water-cooled breeder. DOE, with input from the nuclear industry, will eventually have to decide whether both of these technologies, one of them, or neither of them should be developed commercially. Whether the nuclear industry would be willing to make the capital investment necessary to commercialize two breeder concepts is, at this point, also uncertain.

The liquid metal fast breeder reactor has always been accorded highest development priority by the Federal Government and the nuclear industry. In 1967, the Federal Government evaluated several on-going breeder reactor programs and established the liquid metal fast breeder as having the highest priority. Two reasons for this selection were (1) its proven feasiblity--six small fast breeders were constructed between 1946 and 1963 and (2) more efficient use of the fuel's energy potential.

While it is still uncertain that the water-cooled breeder does breed, the liquid metal fast breeder technology has been demonstrated. Several small liquid metal fast breeder reactors have operated in the United States and for the two largest--the Experimental Breeder Reactors 1 and 2--the Federal Government has positively measured their breeding performance. Also, several larger liquid metal fast demonstration breeders are in operation in other countries. For example, in 1980, the Soviet Union began operating a 600 megawatt plant, and England and France have been operating 250 megawatt plants since 1974. In contrast, the water-cooled breeder has not yet proven that it can breed. Although the Shippingport Station is operating as a small demonstration reactor, the technology will not be completely demonstrated until the proof-of-breeding experiment is completed.

Even if the water-cooled breeder does breed, however, there is no doubt that the liquid metal fast breeder uses fuel more efficiently because of its superior breeding potential. While the water-cooled breeder is only expected to be a self-sustaining reactor--producing enough fuel to refuel itself after covering losses incurred in the recycle process --the liquid metal fast breeder can refuel itself and also provide fuel for additional reactors. Another advantage of the liquid metal fast breeder reactor is its capability to use the spent fuel from existing water-cooled reactors as its initial fuel. In contrast, before a water-cooled breeder

can operate, its fuel must be produced in another reactor called a prebreeder; a dual purpose reactor which provides electrical energy while producing the fuel.

The prebreeder process will require a significant amount of uranium initially and many years of operation to produce fuel for a water-cooled breeder reactor. DOE is studying several prebreeder concepts and has found that the amount of mined uranium ore required and the time required to produce a water-cooled breeder's fuel is directly dependent on the type of prebreeder selected. For example, if an existing reactor vessel is converted to a prebreeder, it must operate 24 years and would require 4,700 tons of uranium ore to fuel a subsequent water-cooled breeder reactor. On the other hand, use of a reactor specifically designed as a prebreeder would require only 3,200 tons of uranium and 18 years of operation to fuel a subsequent breeder. It should be noted, however, that an additional 8 to 10 years would be required to construct a specifically designed prebreeder. For both scenarios, once breeding is obtained, the water-cooled breeder would not require any additional mined uranium ore to operate indefinitely.

It is clear that the water-cooled breeder's breeding potential is significantly less than that of the liquid metal fast breeder reactor. Program officials contend, however, that the water-cooled breeder offers both safety and economic advantages over the liquid metal fast breeder. These contentions, however, have not been proven and are not universally supported. For example, DOE and NRC safety officials have stated that it is not apparent that either system presents more or less of a safety risk than the other. In addition, a recent DOE assessment of competing nuclear technologies concluded that the water-cooled breeder does not appear to offer any significant economic advantages over the liquid metal fast breeder. While questions about the relative safety and economics of these competing technologies must eventually be considered, they are secondary at this point to determining whether the water-cooled breeder breeds. If it does not breed, these issues will be irrelevant. If it does breed, these questions must be addressed in a later stage of reactor development.

Substantial Electric Utility Industry Interest in the Water-Cooled Breeder Must Develop

The Nation's nuclear industry will ultimately decide

electricity. Therefore, to determine the amount of industry interest in the water-cooled breeder program at this time, we surveyed 76 electric utilities, utility associations, and nuclear manufacturers. We did not find an overwhelming interest in pursuing the water-cooled breeder. However, if and when its breeding ability is confirmed, nuclear utilities may take a more active interest in developing the concept. This utility interest must develop if the water-cooled breeder is ever to become commercially viable.

A review of the responses to our questionnaire showed that:

--48 percent felt the program should be reduced or terminated, 30 percent felt it should continue as is, and 22 percent felt it should be expanded.

--over 60 percent felt it should either receive low funding priority or no funding in light of limited resources for all breeder programs; and

--the vast majority of respondents (86 percent) expressed little or no interest in providing either funding or a reactor plant to demonstrate a prebreeder or larger breeder.

We further evaluated the questionnaire responses to concentrate on the views of the thirty-three respondents who had reviewed DOE-sponsored literature on the water-cooled breeder program. We found that:

--56 percent of the respondents felt the program should be reduced or terminated, 22 percent felt it should continue as is, and another 22 percent felt it should be expanded;

--72 percent of those responding felt the water-cooled breeder program should be assigned either a low priority for funding or should not be funded at all in light of the limited resources for all breeder programs; and

--84 percent responding expressed little or no interest in providing a large plant to demonstrate either a prebreeder or breeder and 96 percent responding have little or no interest in providing funding for a large scale demonstration.

DOE recognizes this lack of utility interest in the concept, but believes that the industry should not be

expected to show substantial interest in the technology until after breeding is confirmed. Once the technical results are known, industry can then determine the applicability of the technology. DOE also feels that another factor inhibiting interest in the water-cooled breeder is the general uncertainty about nuclear power. Lastly, DOE officials stated that the Federal Government has not attempted to commercialize the water-cooled breeder so industry should not be expected to show much interest in the program.

Once breeding is confirmed in a water-cooled reactor, the Nation's utilities may take a more active interest in the water-cooled breeder concept. If they do not, however, further development of the concept should not be undertaken.

A Thorium Fuel Cycle Capability Must be Developed

Nuclear powerplants, like the water-cooled breeder, are dependent on several supporting facilities--often called fuel cycle facilities. For the water-cooled breeder reactor to operate commercially, thorium must be mined, converted to fuel, recycled, and refabricated after being used in a pre-breeder and finally disposed of when it becomes waste. Even if the reactor technology is proven to breed, industry cannot use it unless the other fuel cycle facilities are developed and in place.

Any future water-cooled breeder programs geared toward commercializing this concept must include development of its related fuel cycle. The fuel cycle development group has determined that some of the technology development needs of the thorium fuel cycle are consistent with the needs of the liquid metal fast breeder reactor fuel cycle development. Since this group has ongoing programs to develop the liquid metal fast breeder reactor fuel cycle, some requirements for the thorium fuel cycle development can be accommodated in existing programs and facilities. Developing the thorium fuel cycle, however, presents two unique and significant technological problem areas: (1) fabrication of the fuel rods, and (2) solubility of the fuel rods during reprocessing. Development needs are extensive and will require a large amount of development work. Currently, however, DOE has no on-going or planned work for developing the thorium fuel cycle.

Nuclear Fuel Reprocessing is a Precondition for the Existence of a Breeder

All breeder reactor options, including the water-cooled

All breeder reactor options, including the water-cooled breeder, require nuclear fuel reprocessing to be viable. Reprocessing is a chemical process wherein the usable fuel --plutonium or uranium--is separated from the radioactive waste products. The fuel is then fabricated and placed back into the reactor for burning. Without reprocessing, no breeder could be deployed on a commercial scale.

In April 1977, the President proposed that the United States defer all commercial nuclear fuel reprocessing in hope of persuading other nations to do likewise. Nuclear fuel reprocessing produces materials that can be used in nuclear weapons. The President's deferral was an attempt to stop the further proliferation of nuclear weapons by other nations.

No fuel cycle is free of proliferation, but some fuel cycles are more resistant than others. For example, the current generation of nuclear powerplants do not need reprocessing to operate. In both the water-cooled breeder and liquid metal fast breeder fuel cycles, highly purified streams of weapons-usable material are produced. According to DOE, the proliferation-resistance of the two fuel cycles is not significantly different.

In summary, the water-cooled breeder reactor cannot become a commercially viable energy option unless reprocessing is allowed. Any future development must consider the U.S. policy on reprocessing and base the timing of development efforts--in part--on this consideration.

CHAPTER 4

CONCLUSIONS, RECOMMENDATIONS, AND EVALUATION OF AGENCY COMMENTS

CONCLUSIONS

At a time of dwindling energy supplies, the United States is concerned with developing environmentally and economically acceptable energy sources. Events of recent years have made the United States painfully aware of the consequences of dependence on foreign energy supplies. In the immediate future, the United States will probably rely more heavily on its domestic resources--coal and nuclear power--to alleviate requirements for energy sources in short supply, i.e. petroleum.

If nuclear power is to play a long-term role in meeting the nation's energy needs, nuclear powerplants must use fuel more efficiently than they presently do. The water-cooled breeder reactor could provide a means to achieve this objective. Thus, the program should be continued. However, a major question regarding this technology remains unanswered --does the water-cooled breeder use its energy resources more efficiently than current water-cooled reactors, or specifically, "does the water-cooled breeder actually breed?" Before a decision can be made on the next step in developing this technology or on its commercial development, this question must be answered.

DOE, however, has chosen to delay its proof-of-breeding effort. Instead, it plans to extend reactor operation to gather additional information on the thorium fuel system. Although proof-of-breeding, or lack thereof, could be determined now, DOE currently plans to operate the reactor until early 1985. Furthermore, DOE is considering extending reactor operation further. To justify these decisions, DOE revised the program's objectives in 1979 to emphasize maximum fuel and reactor utilization.

In our view, DOE should pursue the overall program goal--demonstrating the reactor's breeding potential--as quickly as possible. We question the value of extending the project to obtain additional information on fuel behavior. DOE plans to obtain this information at a cost of about $200 million without an adequate justification of its potential worth. Until and unless proof-of-breeding is determined, neither

DOE nor the industry can compare the water cooled breeder to other technologies as a basis for reaching decisions on its further development.

Should DOE and the nuclear industry decide that the water-cooled breeder concept warrants further development, several changes must be made to the program management and questions answered on its need before it can become a viable energy technology. First, DOE needs to develop long-term cost and schedule estimates to allow for more accountability for achieving critical steps in the development process. Second, as soon as the proof-of-breeding experiment is complete, responsibility for the program should be transferred to another division currently developing other commercial nuclear reactor fuel systems. This will require the water-cooled breeder to compete with other nuclear technologies for limited Federal energy research and development funds. Finally, DOE must consider various institutional and technical issues surrounding the water-cooled breeder when determining whether to proceed with this concept.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

We recommend the Secretary of Energy:

--Discontinue reactor operation at Shippingport by January 1982 and initiate the proof-of-breeding experiment at that time.

--Establish fixed milestones and cost projections for all major activities so that (1) the performance of the program can be better measured, (2) accountability over achieving critical steps in the development process can be better established, and (3) congressional oversight over program progress can be improved.

--Transfer responsibility for any further development of the water-cooled breeder to the Deputy Assistant Secretary for Nuclear Reactor Programs if such development is warranted.

DOE COMMENTS AND OUR EVALUATION

DOE strongly disagreed with our draft report. Based on DOE's written comments, we made revisions to the report where appropriate.

The basic area of disagreement concerns the question of when proof-of-breeding should occur. DOE currently assigns equal importance to proving breeding and operating the reactor as long as possible to obtain maximum technical data particularly regarding fuel efficiency. We believe that proving breeding is the overriding goal and should not be delayed to meet secondary objectives.

DOE's comments make a number of points revolving around several basic concerns:

--The importance of obtaining additional technical information versus proving breeding as quickly as possible.

--The management and technical success of the water-cooled breeder program.

--The computations of the cost overruns in the program and the additional cost of continuing the program.

--The advantage/disadvantage of the water-cooled breeder relative to the liquid metal breeder reactor.

--The advantage/disadvantage of transferring the program to another DOE division.

In addition, DOE made several other comments relating to (1) recommendations about determining the cost and benefits of and industry interest in the program and (2) the results of our questionnaire on the program.

Our evaluation of DOE's comments follows. The full text of the comments is included as appendix I.

Importance of proving breeding

DOE comments

"* * * GAO takes a narrow focus and concludes that breeding in the light water breeder reactor must be proved now even though shutting down the reactor would not allow realization of the full technical potential of the unique breeder core."

"The GAO concludes that the value of the program hinges on answering the single question of whether the LWBR core does or does not breed, and that the technology to be gained from continued operation of the LWBR core beyond that required to demonstrate breeding is not worth the extra cost. The decision to continue operation of the LWBR core beyond the original design objective of 15,000 to 18,000 Effective Full Power Hours was made because there are advantages to continuing operation and because actual experience shows that the LWBR core is capable of longer operation. The lifetime design objective was set when the development effort started and was based on the state-of-the-art technology. The technology that evolved resulted in a core with a significantly longer lifetime capability. Because of this longer lifetime capability, an economical opportunity is provided to more fully demonstrate the technology of the U-233/Thorium fuel system, providing important technical information not only for evaluating the future potential of LWBR's, but also for more efficient use of nuclear fuel resources in light water reactors. This point was apparently overlooked by GAO. The cost of continuing to operate the LWBR core is justified when considered in relation to the costs of developing, designing, installing and removing the core."

Our evaluation

These DOE comments essentially address the same points: (1) the reactor should continue to operate to provide important technical information and (2) the cost of additional information is justified. Our evaluation of these comments follows.

The report clearly does not say, nor does it infer, that the information to be obtained from continued operation is valueless. We agree the information is useful and may eventually have to be obtained when and if a decision is made to further develop this technology. As discussed on page 16 of the report, however, an all-inclusive commercial demonstration program involving reactor demonstration, fuel cycle capability development, and nuclear industry involvement will be necessary before the water-cooled breeder can be fully commercialized. The outcome of any decision on further development will depend largely on whether the breeding potential of the water-cooled breeder reactor is confirmed. Thus, we disagree with DOE that the information should be obtained now because (1) it will be of questionable value if the reactor does not breed, and (2) other, perhaps less expensive, options exist to obtain this information.

Information we obtained from utilities as well as work done by DOE suggests that if the reactor does not breed, the water-cooled breeder concept will not be considered appealing by the nuclear industry. If this should occur, it is questionable whether the technology will ever be fully developed. Thus, any additional information generated now on the water-cooled breeder fuel may never be used to further demonstrate or commercialize the technology. Although we agree that some information may be obtained that could be applied to light water reactors, this is not the intention of this program; DOE has a separate program with separate funding to improve the fuel efficiency of light water reactors.

Further, we do not believe that DOE has adequately evaluated other options available for obtaining this information. If the reactor breeds, additional information on fuel behavior can be obtained in one of two ways--a test reactor or in a later commercial demonstration reactor.

The use of a test reactor for this purpose is feasible but would take longer than continuing present reactor operation. This method, however, would not delay the proof-of-breeding determination and could be stopped if the reactor does not breed. The fuel can also be further tested in a subsequent larger demonstration reactor. In fact, our position in the report is based on the belief that if breeding is confirmed, a larger demonstration reactor will be required before the water-cooled breeder concept can ever be commercialized. This belief is supported by several factors:

--The nuclear industry--the ultimate purchasers of the concept--has not been involved in the program to date.

--The Shippingport reactor is very small and is not operating at full power.

--The thorium fuel cycle, including reprocessing and refabrication capability, has not been developed for this reactor.

--DOE officials have stated that even after breeding is confirmed, they will not be in a position to assess the costs and benefits of this breeder. Before the utility industry will commit the billions of dollars necessary to commercialize this reactor, it must have a good idea of its cost and benefits. (See DOE comment on p. 33.)

These factors in our view, must be resolved before commercialization of this concept can ever be considered. If we are correct, DOE's decision to delay the proof-of-breeding effort is premature because the information could be obtained through this future stage of development. If we are wrong and DOE can commercialize this technology based on the experience gained at the Shippingport reactor, DOE's approach makes sense. For the reasons cited above, however, we do not believe that to be the case.

Although requested several times, DOE could not provide us with a cost benefit analysis of the various options for obtaining the additional information. We estimate that to obtain the information as DOE currently plans will cost about $200 million. In contrast, testing the fuel in the Advanced Test Reactor in Idaho will cost approximately $15 to $20 million. Further, if a larger demonstration reactor is required before commercialization, the cost of these tests would be absorbed in that program. Given these factors, we continue to question DOE's contention that this is the most economical way to obtain the additional information.

DOE comment

"DOE plans to operate the LWBR installed in the Shippingport Atomic Power Station to provide maximum technical data in the event that application of this option is necessary to meet the Nation's future energy requirements."

Our evaluation

Although this comment is related to the issue discussed above, it deserves a separate evaluation. DOE's plans to operate the LWBR "to provide maximum technical data" is perhaps the central issue upon which our views differ with those of DOE. DOE views this effort as a development program which should be continued as long as possible while we believe the most important aspect of the program should be proving that it breeds as quickly as possible.

At the time of our review, DOE had only approved plans to operate the reactor until January 1982 at which time the reactor will have operated 24,000 fuel power hours--6,000 hours longer than originally approved and according to DOE, more than enough to start the proof-of-breeding experiment. DOE did not mention the possibility of continuing operations for an additional three, and possibly four years, in its official comments, and we did not learn of that decision until after the comments were received.

Although we question DOE's rationale for its initial decision to continue operations to 24,000 hours, the report clearly does not suggest that this effort should be terminated now. We believe the reactor should continue to operate until January 1982 and the proof-of-breeding experiments begun at that time. Our primary concern is that DOE will continue to operate the reactor as long as technically possible--even though it is at less than full power, pressure, and temperature--without an adequate justification of the worth of the information to be obtained. We believe such an analysis should have been prepared for higher level review and approval justifying the extension to the program. Also, for the reasons cited in the previous evaluation, we continue to believe that the proof-of-breeding experiment should begin as quickly as possible.

Program management and success

DOE comment

1. "The thrust of the draft GAO report is that the DOE's Water Cooled Breeder program has been allowed to run out of control from both a cost and a schedular standpoint; that as the program progressed the original objective of operating the LWBR core for three or four years to prove breeding has been revised to emphasize extended operation as well as breeding; and that these result in unwarranted costs."

2. "Inherent in any research and development program is a process of learning and evolution wherein each step of the development effort can potentially result in following a new, previously unexpected path to successful completion. The evolving nature of a research and development effort must be borne in mind when evaluating cost and schedule projections and not equated with lax or improper management. The Water Cooled Breeder program is no exception. This program has been managed, since its inception, to maximize the technical value of the effort. The budget and schedule were adjusted as necessary to reflect the then-current state of knowledge in this very complex technical work."

3. "The GAO places great emphasis on the existence of firm milestones and cost projections as an indicator of proper management and ignores the proven means used by Naval Reactors over the last 30 years to control major technological programs. The GAO suggests that it was not until 1976 that a milestone report was established for the LWBR effort, as if the existence or non-existence of

this report is an indication of the degree of management attention paid to this program. The report on which the GAO places such emphasis as an indicator of sound management, was developed solely to comply with requirements from the Energy Research and Development Administration to provide a report which senior officials of that agency directed be implemented across the board for all programs. That report never was the basis for controlling Naval Reactors' work and was of no value for that purpose."

4. "DOE agrees that milestones and cost projections have a place in controlling work but considers their application must be viewed in the context of a program's overall management."

Our evaluation

With regard to DOE's comments 1 and 2, we disagree that the major thrust of our report deals with DOE's cost and schedule projections and do not feel that we have equated the lack of such projections with overall lax management. Nonetheless, we have made several revisions to the report to clarify our position and recognize (1) DOE's effective day-to-day management of the program and (2) the inherent nature of research and development programs to have schedule and cost overruns.

Regarding comments 3 and 4, we recognized that senior agency officials required milestone reports but program officials feel they are of no value. We do not want to infer, however, that failure to establish and use milestones causes major program delays or cost overruns. However, we believe that senior agency officials and other administrative officials, need such tools--more so than program officials--to chart program progress and accomplishments and to make appropriate changes in direction. In addition, Congress needs such information in making important budgeting decisions. We have revised the report to more clearly state our position and DOE's basis for its position.

DOE comment

"In a similar vein the GAO points to an eight year slippage, or possibly longer, in the completion date of the program. It is true that the core was not installed until four years after the originally estimated date because of unexpected budgetary constraints, technological problems, and the need to upgrade the Shippingport Atomic Power Station to meet requirements that did not exist when the first projections were made. The remainder of the

time arises out of a program decision to operate the core longer. These are not signs of lax management."

Our evaluation

The report never uses the term "lax management." Thus we do not agree that we have attributed the 8-year (now an 11-year) delay to lax management. Nonetheless, we have made several revisions to the report to clarify our position. Specifically, the report has been revised to recognize (1) DOE's position on the delays and (2) DOE's effective day-to-day management.

DOE comment

"Naval Reactors manages the Water Cooled Breeder program the same way it manages the Naval Nuclear Propulsion Program--a program that is well known for exercising strong technical and fiscal control over its work with great attention to detail. This program has been responsible for the design, development and operation of the Navy's nuclear fleet and is currently responsible for 158 operating reactors--more operating reactors than the total of all U.S. civilian nuclear power reactors. In carrying out these programs, effective management and cost control is exercised through strong day-to-day involvement coupled with broad milestones."

Our evaluation

We recognize that DOE's Division of Naval Reactors also manages the Naval Nuclear Propulsion Program, but we did not review the management of that program.

DOE comment

"The GAO seems to overlook the fact that the light water breeder reactor has all the earmarks of a technical success. A light water breeder reactor, believed 20 years ago to be technologically impossible, is operating today in the Shippingport Atomic Power Station and has accumulated 20,000 Effective Full Power Hours (EFPH) of operation. The technology embodied in this breeder opens up for use an energy resource, thorium, that could potentially provide enough energy to meet this Nation's projected requirements for electricity generation for hundreds of years in the future."

Our evaluation

We do not see this comment as being inconsistent with the text of the report. We recognize in the report that the

reactor has operated for more than 3 years and that if the reactor breeds it will offer the potential for long-term nuclear energy generation. Even if it does not breed, we recognize that it opens up for possible use another plentiful energy resource-thorium. Thus, the report does not say, nor does it infer, that the reactor or the program has been unsuccessful.

Nevertheless, the efficiency of the reactor will be reduced tremendously if it does not breed, placing it at a disadvantage when compared to other technologies--such as the liquid metal fast breeder reactor.

In addition, we do not understand what means DOE has employed to measure its technical success. We agree that 20 years ago it was believed to be technologically impossible to breed in a light water reactor. According to DOE, this breeding capability can only be proven by an actual examination of the fuel after being removed from the reactor. To date, this examination has not occurred.

Cost computations

DOE comment

"GAO states that the cost of the LWBR program has increased by a factor of eight. This is erroneous as the GAO has compared a $91.5 million 1965 estimate of the cost to develop, fabricate and install a core with a purported $818 million cost figure which includes operation of the core, the LWBR end-of-life effort, and work subsequently undertaken in the Advanced Water Breeder Applications effort. On an equivalent basis, and in comparable 1965 dollars, the $91.5 million estimate increased by a factor of two, not a factor of eight."

Our evaluation

We do not agree with DOE's estimate or its explanation of what the estimate provided for. First, DOE officials could not provide documentation to support their contention that the $91.5 million estimate was not intended to include operation of the reactor, the proof-of-breeding demonstration, or the subprogram geared toward disseminating technical information to the nuclear industry. Secondly, and perhaps more importantly, DOE documents available to us state that the $91.5 million was intended to provide a "demonstration of breeding potential at Shippingport." Our understanding of "demonstrating breeding potential"--also based on DOE documents--includes installing the breeder core

in an operating reactor, operating it, and then measuring the fuel for breeding. Also, it would appear only logical to us that after completing the demonstration the information would be made available to industry. Thus, all the costs we included are essential to demonstrating the water-cooled breeder's breeding capability. Also, as noted earlier, total program costs will be increased further by about $150 million by DOE's decision to continue reactor operations for another 3 years.

DOE comment

"GAO calculates the additional cost of continued operation of the LWBR core beyond 18,000 EFPH at $50 million per year. This figure is overstated by about a factor of two. The figure used by the GAO includes the cost of work which is not significantly affected by the continued operation of the LWBR core, specifically, preparations for the LWBR end-of-life effort and the Advanced Water Breeder Applications work. The annual incremental cost (in 1982 dollars) of operating the LWBR core beyond 18,000 EFPH is approximately $20 to $25 million per year."

Our evaluation

We disagree with DOE's comment. First, DOE contends that the subprogram geared toward disseminating information to the nuclear industry would not be affected by the continued operation of the LWBR core. We do not understand DOE's rationale for this since this subprogram will also be continuing while the reactor continues to operate--a period of time previously unplanned for. Unless this subprogram is scheduled to end earlier than the remainder of the program--which we do not believe to be the case--we do not understand why these costs should not be included in the overall increased cost.

DOE also contends that costs for preparing the end of life effort should not be included in the increased cost estimate. Based on cost schedules provided us by DOE, funds for this effort have been apportioned for operating the reactor until 1985 and thus have been included in our cost estimate.

Advantages/Disadvantages of the Water-Cooled Breeder

DOE comment

"The GAO does not evaluate the Water Cooled Breeder program from the broad perspective of future national

energy concerns and with an appreciation of the status of other comparable programs."

"In discussing the LWBR program the GAO emphasizes the uncertainties associated with light water breeder technology without giving comparable emphasis to uncertainties inherent in other forms of breeder reactors. The report, therefore, conveys the impression of a strong bias against the LWBR in relation to the Liquid Metal Fast Breeder Reactor (LMFBR). In pointing out the lower breeding potential of the LWBR core compared to the LMFBR, the GAO labels the LWBR an "inferior breeder." It credits the LMFBR as being a proven breeder, based strictly on theoretical calculations. At the same time the GAO emphasizes that Government and industry will not know whether the LWBR core actually bred until the core is removed, segments of the core are dissolved and actual direct measurements are taken of the amount of fissionable material remaining in the core after operation as compared to the initial load. This proof-of-breeding work is particularly important in the case of the LWBR and needs to be done. However, the GAO should recognize that if reactors can be classified as "breeders" based strictly on theoretical calculations and predictions, the LWBR is already as "proven" as any other U.S. breeder concept."

Our evaluation

We do not agree with the text of these comments. First, we believe we have clearly established in the report the importance of breeding capability to the existence of a long-term nuclear option.

Secondly, our discussions of the history and relative priority accorded the LMFBR were based on DOE documents, including DOE's reference to the LMFBR as a "superior" breeder. Thus, it is rather curious that DOE cites this as our "bias" when the reasons cited emphasizing the LMFBR over the LWBR were based on DOE's own documents.

Lastly, we do not understand why DOE disagrees with our assessment of the LMFBR as a proven breeder and claims that we based it on "theoretical calculations." The breeding ability of the LMFBR was measured by the Energy Department in the United States in 1964 for the Experimental Breeder Reactor I and again after a 7-year program conducted at the Experimental Breeder Reactor II. Furthermore, the French have measured the breeding ability of the Phoenix LMFBR. Thus, the breeding potential of the LMFBR has been "proven." On the other hand, the breeding capability of the LWBR is far from certain. In fact, the margin of difference between

breeding and not breeding in the LWBR is expected to be very small and thus, it is uncertain whether it will even breed. Changes have been made to the report to more clearly show that the LMFBR's breeding capability has been "proven."

Transferring the water-cooled breeder program

DOE comment

"The GAO further recommends that the Water Cooled Breeder program be transferred to the Office of Nuclear Reactor Programs. The DOE considers contrary to the GAO, that there is no advantage at this time to change technical and financial responsibility within DOE for the Water Cooled Breeder program. This program comes under the cognizance of the Office of Naval Reactors because of that organization's extensive experience in developing water cooled reactors for the Nation's nuclear powered warships and as a logical outgrowth of previous Naval Reactors civilian nuclear power development work. If at some future date circumstances should change, a shift in program cognizance would be carefully considered."

Our evaluation

We disagree. The report clearly states that we believe that program responsibility should be shifted after the proof-of-breeding experiment is complete and a decision is made to further develop and demonstrate the water-cooled breeder's commercial potential--not "at this time" as stated in DOE's comments. In fact, in early discussions with program officials we were told that the program would likely be transferred after proof-of-breeding.

Other comments

DOE comment

"The GAO recommends that a report be prepared detailing the proof-of-breeding results, potential LWBR cost and benefits, and utility industry interest. An extensive effort is being carried out to document LWBR technology - to date over 300 technical reports have been issued to industry. The results of the proof-of-breeding work will be fully documented as part of this effort. An assessment at this time of potential LWBR cost and benefits is premature. Commercial application of the LWBR, or any other breeder technology, is years away and major technical and policy issues concerning nuclear power must be settled as noted

by GAO. During this time many changes will occur in the overall energy situation in this country that presently cannot be anticipated, negating the value and meaning of any current assessment."

Our evaluation

We agree with this comment. Accordingly, the report has been revised to delete this recommendation.

DOE comment

"DOE notes that the results of the GAO's own questionnaire show that 52 percent of the Nation's major electric power utilities and manufacturers consider the LWBR effort should be continued at its present level or expanded."

Our evaluation

We agree that this comment is accurate--30 percent feel the program should continue as is and 22 percent feel it should be somewhat expanded. The questionnaire also shows, however, that of these 52 percent, 73 percent have little or no interest in providing a plant for further demonstration of breeding and 81 percent have little or no interest in providing funding. We feel this point is important and have revised our presentation of the questionnaire data in the report to more clearly represent the results.

APPENDIX I

Department of Energy
Washington, D.C. 20585

FEB 27 1981

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

Dear Mr. Peach:

The Department of Energy (DOE) appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report entitled: "Does the Water Cooled Breeder Reactor Breed - the Department of Energy Should Find Out Now." DOE strongly disagrees with the GAO draft report. The GAO does not evaluate the Water Cooled Breeder program from the broad perspective of future national energy concerns and with an appreciation of the status of other comparable programs. Instead, GAO takes a narrow focus and concludes that breeding in the light water breeder reactor must be proved now even though shutting down the reactor would not allow realization of the full technical potential of the unique breeder core.

The GAO seems to overlook the fact that the light water breeder reactor has all the earmarks of a technical success. A light water breeder reactor, believed 20 years ago to be technologically impossible, is operating today in the Shippingport Atomic Power Station and has accumulated 20,000 Effective Full Power Hours (EFPH) of operation. The technology embodied in this breeder opens up for use an energy resource, thorium, that could potentially provide enough energy to meet this Nation's projected requirements for electricity generation for hundreds of years in the future.

The thrust of the draft GAO report is that the DOE's Water Cooled Breeder program has been allowed to run out of control from both a cost and a schedular standpoint; that as the program progressed the original objective of operating the LWBR core for three or four years to prove breeding has been revised to emphasize extended operation as well as breeding; and that these result in unwarranted costs. The GAO concludes that the value of the program hinges on answering the single question of whether the LWBR core does or does not breed, and that the technology to be gained from continued operation of the LWBR core beyond that required to demonstrate breeding is not worth the extra cost.

The decision to continue operation of the LWBR core beyond the original design objective of 15,000 to 18,000 Effective Full Power Hours was made because there are advantages to continuing operation and because actual experience shows that the LWBR core is capable of longer operation. The lifetime design objective was set when the development effort started and was based on the state-of-the-art technology. The technology that evolved

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resulted in a core with a significantly longer lifetime capability. Because of this longer lifetime capability, an economical opportunity is provided to more fully demonstrate the technology of the U-233/Thorium fuel system, providing important technical information not only for evaluating the future potential of LWBR's, but also for more efficient use of nuclear fuel resources in light water reactors. This point was apparently overlooked by GAO. The cost of continuing to operate the LWBR core is justified when considered in relation to the costs of developing, designing, installing and removing the core.

The major value of the Water Cooled Breeder program, or any other breeder program, is the nearly inexhaustible energy resource it would make available for future generations. Whether breeding performance is confirmed in 1986 or 1988 will make little difference. However, the amount of technical information to be gained by continuing to operate the LWBR core could be very important in properly applying and exploiting this technology with minimum wasted effort and cost. Thus, while it is important to complete operation of the Shippingport LWBR core, examine the spent core, and confirm breeding performance, a difference of a few years in the date when this technical information will be available is not of paramount importance - particularly in view of the current status of policy and technical uncertainties which have to be resolved before any breeder can be viable.

Inherent in any research and development program is a process of learning and evolution wherein each step of the development effort can potentially result in following a new, previously unexpected path to successful completion. The evolving nature of a research and development effort must be borne in mind when evaluating cost and schedule projections and not equated with lax or improper management. The Water Cooled Breeder program is no exception. This program has been managed, since its inception, to maximize the technical value of the effort. The budget and schedule were adjusted as necessary to reflect the then-current state of knowledge in this very complex technical work.

GAO states that the cost of the LWBR program has increased by a factor of eight. This is erroneous as the GAO has compared a $91.5 million 1965 estimate of the cost to develop, fabricate and install a core with a purported $818 million cost figure which includes operation of the core, the LWBR end-of-life effort, and work subsequently undertaken in the Advanced Water Breeder Applications effort. On an equivalent basis, and in comparable 1965 dollars, the $91.5 million estimate increased by a factor of two, not a factor of eight.

In a similar vein the GAO points to an eight year slippage, or possibly longer, in the completion date of the program. It is true that the core was not installed until four years after the originally estimated date because of unexpected budgetary constraints, technological problems, and the need to upgrade the Shippingport Atomic Power Station to meet requirements that did not exist when the first projections were made. The remainder of the time arises out of a program decision to operate the core longer. These are not signs of lax management.

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The GAO places great emphasis on the existence of firm milestones and cost projections as an indicator of proper management and ignores the proven means used by Naval Reactors over the last 30 years to control major technological programs. The GAO suggests that it was not until 1976 that a milestone report was established for the LWBR effort, as if the existence or non-existence of this report is an indication of the degree of management attention paid to this program. The report on which the GAO places such emphasis as an indicator of sound management, was developed solely to comply with requirements from the Energy Research and Development Administration to provide a report which senior officials of that agency directed be implemented across the board for all programs. That report never was the basis for controlling Naval Reactors' work and was of no value for that purpose.

DOE agrees that milestones and cost projections have a place in controlling work but considers their application must be viewed in the context of a program's overall management. Naval Reactors manages the Water Cooled Breeder program the same way it manages the Naval Nuclear Propulsion Program - a program that is well known for exercising strong technical and fiscal control over its work with great attention to detail. This program has been responsible for the design, development and operation of the Navy's nuclear fleet and is currently responsible for 158 operating reactors - more operating reactors than the total of all U.S. civilian nuclear power reactors. In carrying out these programs, effective management and cost control is exercised through strong day-to-day involvement coupled with broad milestones.

GAO calculates the additional cost of continued operation of the LWBR core beyond 18,000 EFPH at $50 million per year. This figure is overstated by about a factor of two. The figure used by the GAO includes the cost of work which is not significantly affected by the continued operation of the LWBR core, specifically, preparations for the LWBR end-of-life effort and the Advanced Water Breeder Applications work. The annual incremental cost (in 1982 dollars) of operating the LWBR core beyond 18,000 EFPH is approximately $20 to $25 million per year.

In discussing the LWBR program the GAO emphasizes the uncertainties associated with light water breeder reactor technology without giving comparable emphasis to uncertainties inherent in other forms of breeder reactors. The report, therefore, conveys the impression of a strong bias against the LWBR in relation to the Liquid Metal Fast Breeder Reactor (LMFBR). In pointing out the lower breeding potential of the LWBR core compared to the LMFBR, the GAO labels the LWBR an "inferior breeder." It credits the LMFBR as being a proven breeder, based strictly on theoretical calculations. At the same time the GAO emphasizes that Government and industry will not know whether the LWBR core actually bred until the core is removed, segments of the core are dissolved and actual direct measurements are taken of the amount of fissionable material remaining in the core after operation as compared to the initial load. This proof-of-breeding work is particularly important in the case of the LWBR and needs to be done. However, the GAO should

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recognize that if reactors can be classified as "breeders" based strictly on theoretical calculations and predictions, the LWBR is already as "proven" as any other U.S. breeder concept.

The GAO recommends that a report be prepared detailing the proof-of-breeding results, potential LWBR cost and benefits, and utility industry interest. An extensive effort is being carried out to document LWBR technology - to date over 300 technical reports have been issued to industry. The results of the proof-of-breeding work will be fully documented as part of this effort. An assessment at this time of potential LWBR cost and benefits is premature. Commercial application of the LWBR, or any other breeder technology, is years away and major technical and policy issues concerning nuclear power must be settled as noted by GAO. During this time many changes will occur in the overall energy situation in this country that presently cannot be anticipated, negating the value and meaning of any current assessment. DOE notes that the results of the GAO's own questionnaire show that 52 percent of the Nation's major electric power utilities and manufacturers consider the LWBR effort should be continued at its present level or expanded. DOE sees no merit in further study of utility interest until there is a meaningful reduction in the uncertainties associated with nuclear power.

The GAO further recommends that the Water Cooled Breeder program be transferred to the Office of Nuclear Reactor Programs. The DOE considers, contrary to the GAO, that there is no advantage at this time to change technical and financial responsibility within DOE for the Water Cooled Breeder program. This program comes under the cognizance of the Office of Naval Reactors because of that organization's extensive experience in developing water cooled reactors for the Nation's nuclear powered warships and as a logical outgrowth of previous Naval Reactors civilian nuclear power development work. If at some future date circumstances should change, a shift in program cognizance would be carefully considered.

The DOE considers the Water Cooled Breeder program being carried out by DOE's Office of Naval Reactors is well managed and is an important part of the DOE's energy research and development effort. This energy option is being pursued because of the vast energy potential embodied in the LWBR technology. DOE plans to operate the LWBR installed in the Shippingport Atomic Power Station to provide maximum technical data in the event that application of this option is necessary to meet the Nation's future energy requirements.

The GAO is understood to be revising this draft report. The revision may mitigate some of these comments.

Sincerely,

P. Marshall Ryan
Controller

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

SUITE 2321 RAYBURN HOUSE OFFICE BUILDING

WASHINGTON, D.C. 20515

May 2, 1980

APPENDIX II

The Honorable Elmer B. Staats
Comptroller General
U.S. General Accounting Office
441 "G" Street, N.W.
Washington, D. C. 20548

Dear Mr. Staats:

I am writing to request that the GAO conduct two related studies concerning the Department of Energy's research and development programs. The first concerns the realism of DOE's program goals in improving uranium utilization in light water reactors (LWR), and the second concerns the advisability of continuing the DOE's light water breeder reactor (LWBR) program.

As you know, the Subcommittee on Energy Research and Production, which I chair, authorizes and oversees all of the Department's nuclear energy research and development programs. The two specific programs noted above have been identified as activities which may require Congressional redirection. However, further information needs to be developed before responsible action can be taken.

In particular, your investigation of the LWR uranium utilization program should consider the realism of program goals, and should also consider relevant technical and regulatory problems, and the Department's progress toward resolving these problems. Concerning the LWBR program investigation, particular emphasis should be given to (1) the logic for continuing the program in view of the Administration position on reprocessing and the Congress' firm commitment to the fast breeder reactor; (2) how well the program has been managed; and (3) what steps are necessary to fully commercialize the technology.

It would be helpful, if these reports could be available by January 30, 1981 to aid us in consideration of the FY 1982 budget. Should questions arise concerning the topics to be covered, please contact Mr. Stephen Lanes of the Committee staff at 225-8056.

Thank you for your cooperation on this matter.

Sincerely,

Mike McCormack, Chairman
Subcommittee on Energy
Research and Production

APPENDIX III

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APPENDIX IV

U.S. GENERAL ACCOUNTING OFFICE

LIGHT WATER BREEDER REACTOR PROGRAM SURVEY

INSTRUCTIONS

Please answer each of the following questions as frankly and completely as possible.

The questionnaire is numbered only to permit us to delete your name from our list when we receive your completed questionnaire and thus avoid sending you an unnecessary follow up request.

There is space at the end of the questionnaire for any comments you may wish to make concerning the questionnaire, or any other related topics.

If you have any questions please do not hesitate to call Michael Keppel or Darryl Wittenburg at (412) 644-4675. See footnote a/

1. Which statement best describes your familiarity with the light water breeder reactor option for electric power generation? (Check one.)

   1. /4/ We are familiar with the reactor's technology and we have evaluated its commercial applicability. (GO TO QUESTION 2)
   2. /32/ We are familiar with the reactor's technology. (GO TO QUESTION 2)
   3. /30/ We have limited familiarity with the reactor's technology. (GO TO QUESTION 2)
   4. /6/ We are not familiar with the reactor's technology. (GO TO QUESTION 9)

2. Have you reviewed Department of Energy sponsored information concerning the light water breeder reactor? (Check one.)

   1. /33/ Yes
   2. /33/ No

3. Considering the reality of limited resources, what funding priority would you assign to the following breeder programs? (Check one column for each program.)

	High priority	Medium priority	Low priority	Should not be funded
1. Advanced converter reactor	6	17	26	13
2. Gas cooled fast reactor	11	22	19	12
3. Light water breeder reactor	3	20	26	15
4. Liquid metal fast breeder reactor	52	8	4	0

4. Do you believe that the light water breeder reactor program should be expanded, reduced or remain as is? (Check one.)

   1. /2/ program should be greatly expanded (GO TO QUESTION 6)
   2. /12/ program should be somewhat expanded (GO TO QUESTION 6)
   3. /19/ program should continue as is (GO TO QUESTION 6)
   4. /9/ program should be somewhat reduced (GO TO QUESTION 6)
   5. /22/ program should be greatly reduced or terminated (GO TO QUESTION 5)

5. Why do you believe that the light water breeder program should be terminated?

   Discussed in Chapter III

6. Assuming the light water breeder reactor does breed, what should the Department of Energy do next? (Check all that apply.)

   1. /13/ Develop larger scale demonstration prebreeder and breeder units
   2. /24/ Develop the necessary fuel cycle technology and facilities for a thorium/uranium-233 fuel cycle
   3. /18/ Do no further development
   4. /14/ Other (please specify) _____
   5. /7/ Uncertain

a/Seventy-six questionnaires were sent. Four utilities chose not to participate and several respondents did not answer all questions. Number in boxes.

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7. Assuming the light water breeder reactor is proven to breed, how interested would you be in participating in the following cooperative programs? (Check one column for each program.)

	Extent of Interest: Great interest (1)	Some interest (2)	Little or no interest (3)
1. Provide a large scale reactor plant to demonstrate either a prebreeder or a breeder	3	6	51
2. Provide funding to DOE to demonstrate a large scale prebreeder or breeder	0	8	51
3. Provide funding and/or technical support to DOE to develop the thorium/uranium-233 fuel cycle	1	17	42
4. Provide funding to DOE for construction of pilot and demonstration thorium/uranium-233 fuel cycle facilities	0	8	51

8. Compare the light water breeder reactor (LWBR) with the Liquid Metal Fast Breeder Reactor (LMFBR) and the current Light Water Reactors (LWR) based on the factors shown below. Check to indicate whether the light water breeder has major advantages or major disadvantages. (Check one column for LMFBR comparison and one column for LWR comparison)

GAO note: This question confused many respondents and was not used in our analysis.

Area of LWBR Advantage or Disadvantage	LMFBR: Major advantage	LMFBR: No major advantage or major disadvantage	LMFBR: Major disadvantage	LMFBR: No basis to judge	LWR: Major advantage	LWR: No major advantage or major disadvantage	LWR: Major disadvantage	LWR: No basis to judge
1. Proven technology								
2. Nuclear fuel efficiency								
3. Licensability								
4. Cost of construction								
5. Cost of generation								
6. Developmental effort required								
7. Proliferation resistance								
8. Diversification of energy supply								
9 Reprocessing requirement								
10. Breeding ratio								
11. Commercial applicability								
12. Time to commercially available status								
13. Inexhaustible energy source								
14. Decreasing demand for electricity								

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ADDITIONAL COMMENTS

9. If you have additional information which you feel is relevant to any of the preceding questions, or if you have comments about questions we should have asked but did not, please feel free to express your views.

Discussed in Chapter III

APPENDIX V

RECIPIENTS OF GAO QUESTIONNAIRE ON WATER-COOLED BREEDER REACTOR

UTILITY COMPANIES

Alabama Power Co.

Appalachian Power Co.

Arizona Public Service Co.

Arkansas Power and Light Co.

Baltimore Gas and Electric

Carolina Power and Light Co.

Central Power and Light Co.

Cincinnati Gas and Electric Co.

Cleveland Electric Illuminating Co.

Columbus and Southern Ohio Electric Co.

Commonwealth Edison

Consolidated Edison Co.

Consumers Power

Dallas Power and Light Co.

The Dayton Power and Light Co.

Detroit Edison Co.

Duke Power Co.

Duquesne Light Co.

Florida Power Corporation

Florida Power and Light Co.

Georgia Power Co.

Gulf States Utilities

Houston Lighting and Power Co.

Illinois Power Co.

Indiana and Michigan Electric Co.

Kansas City Power and Light

Long Island Lighting Co.

Los Angeles Department of Water and Power

Louisiana Power and Light Co.

Metropolitan Edison Co.

Monongahela Power Co.

New England Electric System

Niagra - Mohawk Power Co.

Northern Indiana Public Service Co.

Northern States Power Co.

Ohio Edison Co.

Ohio Power Co.

Oklahoma Gas and Electric Co.

Pacific Gas and Electric Co.

Pacific Power and Light Co.

Pennsylvania Electric Co.

Pennsylvania Power and Light Co.

Philadelphia Electric Co.

Potomac Electric Power Co.

Power Authority of the State of New York

Public Service Company of Colorado

Public Service Company of Indiana, Inc.

Public Service Company of Oklahoma

Public Service Electric and Gas

Salt River Project

San Antonio City Public Service Board

South Carolina Electric and Gas

Southern California Edison

Southwestern Electric Power Co.

Southwestern Public Service Co.

Tampa Electric Co.

Tennessee Valley Authority

Texas Electric Service Co.

Texas Power and Light Co.

Union Electric Co.

U.S. Army Corps and Engineers (North Pacific Division)

U.S. Bureau of Reclamation (Pacific Northwest Region)

Virginia Electric Power Co.

West Penn Power Co.

Wisconsin Electric Power Co.

UTILITY INDUSTRY ORGANIZATIONS

American Public Power Association

Atomic Industrial Forum

Edison Electric Institute

National Electric Reliability Council

National Rural Electric Cooperative Association

Electric Power Research Institute

VENDORS

Babcock and Wilcox

Combustion Engineering

General Atomic

General Electric Co.

Westinghouse Electric Corp.

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