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REPORT BY THE

Comptroller General

OF THE UNITED STATES

The Liquid Metal Fast Breeder Reactor--Options For Deciding Future Pace And Direction

The Liquid Metal Fast Breeder Reactor (LMFBR) program is a research and development program intended to develop breeder reactor technology as a long-term electricity supply option. Controversy surrounding the program--and the Clinch River Breeder Reactor demonstration project--over the last several years has led to shifts in program direction, delays in constructing the Clinch River project, and a lack of focus for the LMFBR program.

This report (1) summarizes GAO's work in recent years on both the LMFBR program and the Clinch River project, (2) provides a current perspective on nuclear power from which to guide the current breeder program, and (3) presents information on options available to congressional decisionmakers for their use in deciding on the program's future pace and direction.

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JULY 12, 1982

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

B-208047

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

Dear Madam Chairman:

This report responds to your November 5, 1981, request that we assess our past positions on the Clinch River Breeder Reactor.

As arranged with your office, we are sending copies of the report to interested parties and we will make copies available to others upon request.

Sincerely yours,

Charles A. Bowsher

Comptroller General
of the United States

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

THE LIQUID METAL FAST
BREEDER REACTOR--OPTIONS
FOR DECIDING FUTURE PACE
AND DIRECTION

D I G E S T

The Liquid Metal Fast Breeder Reactor (LMFBR) offers the promise of providing this country with a long-term energy source. Since the mid-1970s, however, the LMFBR program in general and the Clinch River Breeder Reactor--a plant designed to demonstrate breeder technology--has been controversial. This controversy began with concern over nuclear proliferation. Since the fuel of the LMFBR contains plutonium, which can be used to make nuclear weapons, there was the concern that constructing the Clinch River Breeder Reactor would hinder efforts to prevent other countries from developing breeder reactors and other nuclear technologies which could be used to make nuclear weapons. The Carter Administration attempted to cancel the Clinch River project while maintaining a strong breeder program aimed at studying other potentially more proliferation-proof breeder concepts.

During the Carter years, the Congress continued to fund the project and an impasse developed. Along with the proliferation issue, the debate included safety, timing of breeder reactor deployment, and comparing the breeder against other energy technologies.

While the Reagan Administration now supports the LMFBR program and the Clinch River Breeder Reactor--it is one of the highest priority programs in the energy budget--the controversy has not subsided. Rather, increased interest in controlling Federal spending and reducing the Federal deficit has resulted in comparison of the program and the project not only against other energy technologies but also against non-energy programs and policies.

The Department of Energy expects to spend about $584 million during fiscal year 1982 and is requesting $523 million in fiscal year 1983 for the breeder program. This request includes $253 million for the Clinch River project. In total, about $6 billion has been spent on the LMFBR program from 1966 through fiscal year

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1981, including about $1 billion on the Clinch River project.

The following sections (1) summarize past GAO work on the LMFBR program and the Clinch River project, (2) present a current perspective on nuclear power from which to judge the pace and direction of the LMFBR program, and (3) discuss the fundamental options open to the Congress in deciding on the future pace and direction of the program.

PAST GAO WORK

GAO has reported on numerous aspects of the LMFBR program and the Clinch River project over the past 7 years. The three most comprehensive reports on the program and/or project were issued in 1975, 1979, and 1980. In those reports GAO generally supported the view that a strong LMFBR program is needed if nuclear fission is to be a long-term energy source. Some of GAO's major findings included:

--The LMFBR program should be clearly identified and recognized for what it is--a research and development program.

--The Clinch River project is the next logical step in the research and development process to obtain valuable information on the performance, reliability, maintainability, safety, environmental acceptability, licensability, and economic feasibility of the breeder concept in a utility-type environment.

--The Clinch River project is not an irrevocable step toward commercial deployment of an LMFBR-type breeder reactor.

--Terminating the Clinch River project would not reduce proliferation risks.

--There will always be some uncertainty associated with predicting future conditions and/or events, thus making projections difficult. These uncertainties include such things as availability of uranium, breeder reactor economics, and constraints on domestic coal supplies.

GAO's 1980 report also discussed the problems program managers were facing in maintaining a focus for the program in the face of the continuing controversy over the Clinch River Breeder Reactor. GAO continues to hold to these earlier findings. (See p. 7.)

A CURRENT PERSPECTIVE ON NUCLEAR POWER FROM WHICH TO JUDGE THE PACE AND DIRECTION OF THE LMFBR PROGRAM

There has been a continual erosion in the government's estimates of anticipated growth of nuclear power. In 1972 the Atomic Energy Commission projected that anywhere from 800 to 1,500 nuclear power plants would be on line by the year 2000. The Department of Energy now projects approximately 145 to 185 nuclear power plants by that year. The decline is further evidenced by both nuclear power plant cancellations and deferrals and lack of orders for new nuclear plants. This situation is primarily due to low electric power demand growth rates, the utility industry's generally poor financial condition, and the capital-intensive nature of nuclear power. It also stems from a lack of agreement on the best way to dispose of highly radioactive waste.

When these conditions and problems are collectively examined, it becomes apparent that the outlook for nuclear power in this country is unlikely to improve until conditions change and the problems are resolved. Nevertheless, nuclear power still remains an important energy source. Over the years the use of nuclear power has increased as an energy source and currently comprises approximately 13 percent of the Nation's electrical generating capacity. The Department expects that nuclear energy will soon be second only to coal as an energy source for generating electricity. Furthermore, it is a domestic energy source that can provide additional electrical capacity should the potential environmental problems with coal limit the use of that domestic energy source. (See p. 13.)

Against this backdrop, GAO examined its previous positions on the Department's breeder reactor program and the Clinch River Breeder Reactor in terms of answering three questions which affect the pace and direction of the program and the continuing need for the Clinch River demonstration plant. In considering the answers to these questions, it is important to recognize that (1) there is much uncertainty inherent in projecting trends and/or events such as electricity and nuclear power growth far into the future, and (2) the LMFBR is still a research and development program, not a commercially deployable energy technology. The three questions, and a summary of the answers to them are:

--How long can domestic uranium supplies fuel conventional nuclear reactors? Based on the Department's latest projections on the growth of nuclear power and available domestic uranium supplies, uranium supplies appear adequate to fuel conventional reactors well past the year 2020. These projections do not take into account possible advances that may occur in mining and using uranium, or the effect of imports and exports of uranium over this time period. (See p. 15.)

--When will breeder reactors be economical? The Department's most recent study shows that a commercial breeder reactor would most likely be economical in the 2025 to 2035 time frame. Over the years projections of breeder reactor costs as well as projections of nuclear power use have been changing and extending further into the future the time a breeder reactor will likely be economical. (See p. 21.)

--Is the Clinch River project still an important and necessary step in developing the breeder option? As it has in the past, GAO continues to believe that a Clinch River-type demonstration project is a necessary step in developing the breeder option. If the LMFBR is to be developed to the point where industry can use it, an intermediate-sized plant such as the Clinch River project is a logical and prudent step to gain important operational experience on breeder reactor performance, reliability, maintainability, safety, environmental acceptability, licensability, and economic feasibility. (See p. 23.)

LMFBR PROGRAM OPTIONS

The above perspective presents several development courses to LMFBR decisionmakers. To assist the Congress in its decision, GAO discusses the tradeoffs of three fundamental options.

1. Continue the program as spelled out in the Department's May 1982 LMFBR program environmental impact statement. This includes

constructing the Clinch River Breeder Reactor as soon as possible and a large development plant with substantial industry financial support by the mid-1990s, thus permitting a possible commercial decision to build a breeder a few years thereafter.

Continuing the present program provides the best assurance that breeders will be available when needed and provides the focus lacking in the LMFBR program over the past several years. In addition, Department officials believe the present program would keep the Nation competitive with foreign LMFBR programs and would represent a symbol to the nuclear industry that the Nation is making a commitment to the long-term future of nuclear power. On the other hand, this approach has substantial budgetary costs in the short term. Further, if the Department's current plans are followed, a breeder reactor could be developed well before it is needed or economically competitive--that is, well before there is enough incentive for utilities to order breeder plants. (See p. 26.)

2. Restructure the program. This option centers around the timing for building and operating both the Clinch River Breeder Reactor and the follow-on large development plant. The tradeoffs associated with this option vary depending on how and to what extent the program is restructured. Several examples include:

--Complete the Clinch River project as currently planned by DOE while delaying the large development plant. Such an approach would (1) allow more time for making a decision on when to build the larger plant as well as its appropriate size and design, and (2) enable the Department and industry to better incorporate Clinch River operating experience into the final design of the large development plant. This operational experience could be critical in looking at ways of reducing the capital costs associated with breeders. Finally, this approach would allow more time to fully develop a sound commercial breeder reactor industry. In this regard, a number of industry spokesmen told GAO that the Department's current plan could result in too rapid development of breeder reactors--a situation which they believe occurred with the light water reactor technology now in use. On the other hand, budget savings would not accrue immediately under this approach. In addition, according to the Department, it could lead to the erosion of the infrastructure that will be needed for future LMFBR commercialization. (See p. 28.)

--Defer both the Clinch River Breeder Reactor and large development plant for an indefinite period. Adopting this approach would (1) result in short-term budgetary savings but might increase total LMFBR program costs; (2) provide an opportunity to reassess funding priorities; (3) allow decisionmakers time to assess whether utilities are likely to resume ordering new nuclear power plants and at what rate, and reconsider the structure and pace of the entire LMFBR program. According to Department officials--and as generally supported by industry officials--this approach could result in breeder technology not being available when needed if there is a change in the demand for nuclear power. They also view demonstration plants as essential to any serious commitment to developing LMFBR technologies and point out that without operating plants there is no significant involvement of industrial suppliers in the LMFBR development program. In addition, they note that construction, startup, operating, and licensing experience will be completely lacking until a demonstration project is built. (See p. 29.)

--Stretch out or temporarily delay construction of the Clinch River Breeder Reactor and/or large development plant. The benefits of this option are similar to the previous option--reduced Federal funding in the short term, and more time to assess the general role of nuclear power and the specific role of breeder reactors in the Nation's energy future. In addition, following this approach would allow more time to test key components for the Clinch River demonstration plant, thereby lowering the development risks associated with building the project. It would also provide time for an immediate technical reassessment of the LMFBR program thereby allowing the Department to examine new concepts, designs, and components that might, for example, lower the capital costs of an LMFBR--the key economic uncertainty affecting the potential deployment of commercial LMFBRs.

In addition to the risks discussed earlier associated with other restructuring approaches, the Department and some industry officials believe that (1) personnel engaged in plant and component design and fabrication will be lost by even a few years delay and that their retrieval will be difficult and expensive; (2) total program costs would increase and, (3) while possibly reducing risks in the near term, this approach may increase risks in the long term by delaying the time when meaningful operational data on breeder reactors could be obtained and squeezing the plant demonstration and technology transfer timetable. (See p. 30.)

3. Terminate the entire LMFBR program. This option would free Government funds for other energy and non-energy programs or for reducing Federal expenditures. On the other hand, choosing this option implies a willingness to possibly foreclose on the long-term future of a major energy option--nuclear fission--thereby relying heavily on other alternative energy technologies such as fusion and solar energy, together with coal, to meet future electrical demand. Alternatively, it implies a willingness to import breeder technology from foreign countries if these other technologies are not developed in time or if environmental problems preclude an expanded use of coal. (See p. 31.)

OBSERVATIONS AND MATTERS FOR CONSIDERATION BY THE CONGRESS

Decisions about the future pace and direction of the LMFBR program and, within that program, the Clinch River Breeder Reactor require policy judgments about many factors which are not quantifiable--the future growth of nuclear power, budget priorities, and possible reliance on foreign technologies and energy sources. In the final analysis, the Congress must make these judgments.

For some years now the LMFBR program in general and the Clinch River project in particular have been surrounded by controversy. This controversy has led to shifts in program direction and efforts to defer or cancel the CRBR demonstration plant. In this environment, it has been difficult for program officials to manage the program and to maintain a focused research, development, and demonstration effort. Proponents and opponents alike have used the same basic information to argue both sides of the issue. GAO believes current decisions regarding the LMFBR program should revolve around two points. The first point is whether this country wants to maintain a nuclear option and wants to commit to nuclear power as a long-term energy source. Clearly, in the past several years, nuclear power's momentum has slowed substantially and the time horizon for when commercial LMFBR may be needed has been pushed further into the future. Nevertheless, nuclear power still remains an important domestic electrical energy option and, depending on future events, could become even more important. The second point is that the LMFBR program should be clearly identified and recognized for what it is--a research and development program--and construction of a Clinch River-type project is the next logical step in the research and development process.

Therefore, although the Congress has three fundamental options available to it--continuing, restructuring, or terminating the LMFBR program--in GAO's opinion the uncertainty inherent in projecting far into the future persuasively argues against the termination option. Thus, GAO believes the prudent choices available to the Congress lie between continuing the LMFBR program along the lines proposed by DOE or restructuring the program with clearly defined and agreed upon objectives. (See p. 33.)

Should the Congress decide to restructure the program, it should request from the Department and others information on, among other things:

--The various options available for restructuring the LMFBR program and the tradeoffs associated with each option.

--Required spending levels for each option.

--The extent to which additional testing of critical demonstration plant components can reduce developmental problems.

--Ways to refocus research efforts to emphasize reducing LMFBR capital costs.

In addition, any decision to refocus the program should include establishing clear goals and objectives on which to focus program efforts. (See p. 36.)

AGENCY COMMENTS

The Department provided official comments on a draft of the report. GAO made changes in the report to reflect the Department's comments and also the views GAO obtained from utility and nuclear industry representatives and nuclear energy experts. The Department stated that it is imperative to proceed with the LMFBR program and the Clinch River project on the current schedule. In the Department's view, a decision to slow the program, if ultimately proven incorrect, would have serious national security implications. The Department said that industrial disruptions, constrained economic growth, and increased reliance on foreign supply can be expected if adequate economic supplies of energy are not available. The full text of the Department's comments is in appendix III beginning on page 40.

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GAO performed this review at the request of the Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology. In addition, GAO received letters from the Chairman, House Committee on Interior and Insular Affairs and the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, expressing interest in the matters discussed in this report. Other committees and members of Congress have expressed similar interest on an informal basis.

Contents

ABBREVIATIONS

AEC	Atomic Energy Commission
CRBR	Clinch River Breeder Reactor
DOE	Department of Energy
ERDA	Energy Research and Development Administration
GAO	General Accounting Office
LMFBR	Liquid Metal Fast Breeder Reactor
NRC	Nuclear Regulatory Commission

CHAPTER 1

INTRODUCTION

Today, 72 commercially owned nuclear power plants account for about 13 percent of this Nation's electrical generating capacity. Another 86 nuclear power plants are either under construction or planned. Virtually all of these plants are conventional water-cooled reactors, usually referred to as light water reactors and fueled with enriched natural uranium. Current generation light water reactors, however, use less than 1 percent of the potentially usable energy in natural uranium. This is because natural uranium contains only a small percentage of fissionable material.

From the nuclear power industry's beginning in the 1950s, both the Federal Government and nuclear industry recognized that, because uranium resources are limited, a long-term nuclear power program would require more efficient use of domestic uranium resources. A number of technological ways to extend uranium resources are available. For example, additional energy can be obtained from spent fuel 1/ through a chemical process called reprocessing. In reprocessing, the residual fissionable uranium and plutonium--which is created during the nuclear fission reaction--is extracted from the spent fuel. Both the fissionable uranium and plutonium can then be used as fresh fuel in reactors. Additionally, more efficient reactors can theoretically be developed to extend domestic uranium reserves. Further, advanced techniques for extracting higher percentages of fissionable material from natural uranium can also be utilized. All these technologies, however, only extend the use of the very small percentage of fissionable material found in natural uranium.

In contrast, breeder reactors have the potential to stretch domestic uranium supplies for hundreds of years. Most of the energy potential in natural uranium remains in the non-fissionable portion (99.3 percent) of the uranium. To tap this energy source, this uranium must first be converted to fissionable material. This can be done in breeder reactors. By surrounding plutonium fuel with a "blanket" of natural uranium, a breeder reactor can both produce electricity and convert the blanket material into plutonium. The fresh plutonium can then be extracted, reprocessed, and used to begin the breeding cycle again. Furthermore, more fresh plutonium fuel is created in the process than is burned--thus the breeder reactor can refuel itself and provide fuel for other breeder

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1/Spent fuel is the used uranium fuel that has been removed from a nuclear reactor.

or conventional reactors. Because of this vast potential of breeder reactors, the Federal Government has, for many years, made one type of breeder reactor--the Liquid Metal Fast Breeder Reactor (LMFBR)--one of its highest priority energy research and development programs.

THE U.S. LMFBR PROGRAM

Since the mid-1960s the development of the breeder reactor has been a major objective of the Federal nuclear power program. In 1967, after several years of study, the Atomic Energy Commission (AEC) 1/ selected the LMFBR concept for development and declared it to have the highest reactor development priority. The LMFBR was selected over other breeder types because of its (1) more efficient use of the energy potential in uranium, (2) industrial support, (3) technological experience, and (4) proven feasibility--six small LMFBRs had been constructed and operated in this country between 1946 and 1963. As currently envisioned, a broadbased LMFBR research and development program would support the cooperative Federal Government/industry construction of a limited number of LMFBR demonstration plants leading to development of the technology to the point where utilities could decide to deploy breeder reactors. Many foreign countries such as France and the United Kingdom have similarly made the development of breeder reactors a high priority program (see app. I).

The overall goal of the breeder program is to ensure that this long-term electricity supply option is available on a prudent time scale. To accomplish this goal, the LMFBR program is designed to develop the technical, engineering, safety, environmental, economic, licensing, and industrial data base required to transfer design, construction, and operation capabilities of future LMFBR power plants to the private sector.

The LMFBR program currently contains three broad elements to ensure that a proven long-term electricity supply option is available: (1) a supporting base technology program including test facilities, (2) supporting fuel cycle programs, and (3) construction and operation of development plants. The base technology program provides the basic data, processes, methods, components, and systems that are used in the LMFBR program to design, construct, fabricate, test, license, and operate LMFBR power plants. The second element includes the development of the LMFBR fuel cycle including fuel reprocessing, fuel fabrication, and waste management.

1/The Atomic Energy Commission and the Energy Research and Development Administration were both predecessors of what is now the Department of Energy. Both of the predecessor agencies were responsible for conducting nuclear energy research and development.

The third element--construct and operate development plants--has become the current focal point of the LMFBR program. Specifically, it currently consists of the construction and operation of the 375 megawatt-electric 1/ Clinch River Breeder Reactor (CRBR) demonstration project. This project is intended to help demonstrate the technical performance, licensability, reliability, maintainability, safety, environmental acceptability, and economic feasibility of an LMFBR central station electric power plant in a utility environment. According to the Department of Energy's (DOE) current plans, the next important step in completing the LMFBR program is to follow the CRBR with the construction and operation of a large development plant by the mid-1990s. Although DOE's latest plans do not specify any demonstration plants beyond the mid-1990s, DOE officials said more demonstration plants may be necessary before utilities will decide to deploy breeder reactors.

Based on information supplied by DOE, about $6 billion has been spent on the LMFBR program from 1966 through fiscal year 1981. DOE expects to spend about $584 million during fiscal year 1982 and is requesting $523 million in fiscal year 1983 for the breeder program. This request includes $253 million for the CRBR project. About $1 billion has been spent on the CRBR project. (See app. II for the detailed cost information on the CRBR project). We have recently received Congressional requests concerning, among other things, the cost of both the CRBR and LMFBR programs. The Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked us to analyze the estimated costs of CRBR. The Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology, asked us to undertake an inventory of information relating to manpower facilities, construction costs, capital equipment costs and other related statistics associated with the DOE's program in breeder reactor systems.

THE CONTROVERSY

Since the mid-1970s, the LMFBR program, and particularly the CRBR project, has been the subject of controversy. The program and the project had strong support from the Nixon Administration in the early 1970s. By the mid-1970s, however, a number of questions and uncertainties about the program began surfacing. In 1976, the Ford Administration expressed concern over safeguarding plutonium--the fuel of the LMFBR--because the plutonium in the fuel could be used to make nuclear weapons. The Carter Administration shared this concern and attempted to cancel the CRBR and redirect the funds for the LMFBR program to study other potentially more proliferation-proof breeder concepts.

1/One megawatt-electric is equal to 1 million watts.

Several studies 1/ concluded, however, that no single path among known nuclear fuel cycles involving reprocessing is substantially less proliferation-prone than another. In addition, studies done by the Nonproliferation Alternative System Assessment Program and the International Nuclear Fuel Cycle Evaluation--two groups established to study the non-proliferation issue--concluded that no technical solution exists to the non-proliferation dilemma because all nuclear fuel cycles entail some proliferation risks. Further, these reports pointed out that with the exception of the conventional light water reactors without fuel reprocessing, other fuel cycles do not offer inherent non-proliferation advantages over the LMFBR.

The Congress funded the program and the project throughout the Carter Administration. The Reagan Administration reversed the Carter position on the CRBR project and the LMFBR program and has again made it one of the highest priority energy research and development projects. Although the Congress has kept funding the CRBR project, it continues to be controversial as evidenced by debates over and close votes on its continuation. During the Carter Administration, the congressional debates centered on proliferation concerns, safety, timing of when a breeder is needed, and comparing the pros and cons of the breeder against other energy technologies. While these are still concerns today, concerns over the size of the Federal deficit have added a new element to the debate on the LMFBR program and the CRBR project. In this regard, the program and the project are now being compared more carefully not only against other technologies but also against non-energy programs and policies.

OBJECTIVE, SCOPE, AND METHODOLOGY

This report responds to a November 5, 1981, request from the Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology, that GAO reassess its past positions on the CRBR project. Because the CRBR project is an integral part of the LMFBR program, we examined both the program and the project in the context of three important questions which affect the pace and direction of the LMFBR program:

--How long can domestic uranium supplies fuel the light water reactor nuclear industry?

--When will breeders be economical?

1/"Alternative Breeding Cycles for Nuclear Power: An Analysis," Congressional Research Service, Library of Congress, Oct. 1978; "Nuclear Proliferation and Safeguards," Office of Technology Assessment, June 30, 1977: "Nuclear Reactor Options to Reduce the Risk of Proliferation and to Succeed Current Light Water Reactor Technology," U.S. General Accounting Office, May 23, 1979.

--Is the CRBR project still an important and necessary step in developing the LMFBR option?

Our work focused on the demonstration projects within the context of the overall program because of the importance of these projects in developing breeder technology. We only examined the LMFBR base technology program as it relates directly to the construction and operation of demonstration plants. We then examined the key trade-offs involved in analyzing the basic options available to LMFBR decisionmakers--continuing, restructuring, or terminating the present program.

In answering these three questions and examining the trade-offs among various options, we interviewed knowledgeable officials from DOE and national laboratories. We also collected, examined, and analyzed a broad array of DOE internal reports, studies, and other pertinent correspondence on the key issues identified. We used DOE data and computers to project uranium requirements for various nuclear growth scenarios and developed examples of the economic viability of breeders versus light water reactors. We independently checked DOE's data and computer projections with our own calculations and other non-government studies to judge the reasonableness of the DOE data. In addition, we reviewed a wide range of studies and professional papers that have been done over the last several years on the economics and timing of breeders. As a result, this report relies heavily on the latest available DOE data regarding the future use of nuclear power, uranium estimates, and the economic viability of breeder reactors versus light water reactors.

In developing options, we relied on our previous work. We also used information that has been recently gathered in conducting audits related directly or indirectly to the LMFBR program including a technical review of selected CRBR components and an assessment of the need for DOE's gas centrifuge enrichment plant. The first audit, which resulted in a report entitled "Revising the Clinch River Breeder Reactor Steam Generator Testing Program Can Reduce Risk" (GAO/EMD-82-75, May 25, 1982), discusses the possible need for more complete and thorough testing of a major CRBR component. The second review, which resulted in a report entitled "Issues Concerning the Department of Energy's Justification For Building The Gas Centrifuge Enrichment Plant" (GAO/EMD-82-88, May 25, 1982) includes a detailed discussion of nuclear energy growth estimates and uranium supply and demand estimates.

Finally, in finalizing this report we solicited utility and nuclear industry views regarding the importance of the CRBR project and the LMFBR program, as well as the views of nuclear energy experts who were formerly involved in the LMFBR program in some capacity. The individuals and the organization we contacted included:

--C. F. Luce, Chairman of the Board, Consolidated Edison Company of New York, Inc.;

--W. S. Lee, President and Chief Operating Officer, Duke Power Company;

--W. B. Behnke, Vice Chairman, Commonwealth Edison, and Chairman, Breeder Reactor Corporation;

--Dr. John Deutch, Dean of Science, MIT and former Undersecretary of Energy;

--Marc Messing, Environmental Consultant;

--Dr. Robert C. Seamans Jr., MIT, and former Administrator, Energy Research and Development Administration;

--Dr. Joseph M. Hendrie, Brookhaven National Laboratory, and former Chairman, Nuclear Regulatory Commission; and

--Atomic Industrial Forum, a membership organization intended to foster development and utilization of atomic energy for peaceful purposes.

We performed our work in accordance with GAO's "Standards for Audit of Government Organizations, Programs, Activities, and Functions."

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Our previous work, major positions, and DOE's comments on those positions are discussed in detail in chapter 2. Chapter 3 provides a current perspective on nuclear power from which to judge the pace and direction of the LMFBR program. Chapter 4 presents our discussion of various options for consideration by the Congress in view of the latest data, and chapter 5 discusses our observations and presents matters for consideration by the Congress. DOE's overall comments on the issues addressed in this report are discussed at the end of chapter 5, and are included in their entirety in appendix III, beginning on page 40.

CHAPTER 2

PAST GAO REPORTS AND POSITIONS

During the past 7 years, we have reported on numerous aspects of the LMFBR program as well as other breeder reactor programs. Our work has ranged from very specific reports, such as contracting arrangements for the CRBR components, to comprehensive reviews of the breeder program and/or CRBR project. Our three most comprehensive reports discussing the need for and timing of the LMFBR program and CRBR project were

--"The Liquid Metal Fast Breeder Reactor: Promises and Uncertainties" (OSP-76-1, July 31, 1975);

--"The Clinch River Breeder Reactor--Should the Congress Continue to Fund It?" (EMD-79-62, May 7, 1979); and

--"U.S. Fast Breeder Reactor Program Needs Direction" (EMD-80-81, Sept. 22, 1980).

In general, these reports have been supportive of both the LMFBR program and the CRBR project, assuming that Congress wanted to commit to nuclear power as a long-term energy source. The following sections summarize the conclusions reached in the three reports in the context of the important issues that were facing the program and the project at the time of each review.

"THE LIQUID METAL FAST BREEDER REACTOR: PROMISES AND UNCERTAINTIES" (OSP-76-1, July 31, 1975)

At the time this report was issued, the Government's forecast of nuclear power generating capacity was, in comparison to current estimates, extremely high. In this report, we pointed out that forecasts for nuclear generating capacity by the year 2000 ranged from 625 to 1,250 gigawatts. 1/ The Energy Research and Development Administration (ERDA) 2/ was using a 1,000 gigawatt figure by the year 2000 for planning purposes. Because the lifetime uranium requirements to meet this capacity exceeded ERDA's preliminary estimates of uranium resources, ERDA expected that commercial breeder reactors would be deployed prior to the year 2000. The CRBR project was to play a key role in this development plan

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1/One gigawatt is equal to 1,000 megawatts. Since commercial power plants are typically sized at about 1,000 megawatts, 625 to 1,250 gigawatts of nuclear power are roughly equivalent to 625 to 1,250 nuclear power plants.

2/The predecessor agency to the Department of Energy.

by demonstrating the reliability, safety, licensability, and environmental acceptability of the LMFBR concept. Also, the CRBR project would provide a major input to the component development programs for future larger plants.

This report examined in detail the uncertainties that surrounded the program. These included, among other things, the rate of growth in the use of electricity in the years ahead, the extent to which nuclear fission would be required to meet ERDA projections, the amount of recoverable uranium, and the eventual economic feasibility of breeders.

In the face of these uncertainties, we reached the following general conclusions:

--The United States clearly should not abandon the nuclear fission option at this time, nor should it abandon the LMFBR research and development effort.

--The LMFBR program should be clearly identified and recognized for what it is--a research and development program.

--Whatever action is taken by the United States on nuclear power and the LMFBR, the problems of nuclear safety and safeguards will not go away.

--The most logical course of action is to pursue the LMFBR program on a schedule which recognizes that the program still is in the research and development stage.

In commenting on this report, ERDA and the former Federal Energy Administration were in general agreement with the above conclusions. ERDA believed, however, that parts of the report presented information that would tend to decrease the urgency of the breeder program without presenting other available information that would be helpful for a more balanced understanding of the need for the LMFBR.

"THE CLINCH RIVER BREEDER REACTOR--SHOULD THE CONGRESS CONTINUE TO FUND IT?" (EMD-79-62, May 7, 1979)

When this report was issued in 1979, the situation surrounding the future use of nuclear power had changed significantly since our 1975 report. Most importantly, significant drops in the projected use of nuclear power raised questions about when the breeder would be needed. In addition, the Carter Administration was attempting to terminate the CRBR project not only because of questions related to when a breeder would be needed but also because of nuclear proliferation concerns and concerns about the project's size and technical value. This report focused on whether the Congress should fund the CRBR project.

In this report we noted that one of the Carter Administration's reasons for wanting to terminate the CRBR project was its belief that commercial breeder reactors would not be needed until about the year 2025. We recognized that commercial breeder reactors might not be needed as soon as had been projected earlier but also pointed out that when they could be needed depended on variables such as electricity growth rates, domestic uranium reserves, and successful research, development, and demonstration of other nuclear and non-nuclear technologies. The uncertainties surrounding these variables as well as the uncertainties of the breeder program's content and pace for the next 45 years, we concluded, argued for continuing the effort to demonstrate breeder reactor technology.

We also noted that both the administration and the Congress wanted to continue a strong LMFBR program. Therefore, this report focused on the importance of continuing the CRBR project in the context of continuing a strong LMFBR program. We found that

--the project was not an irrevocable step toward commercial deployment of the LMFBR-type breeder reactor;

--the project was a logical extension of the LMFBR research and development program and could provide valuable information;

--terminating the project would not reduce proliferation risks; and

--the project was not technically obsolete and its intermediate size was a logical and prudent step in developing the breeder option.

As a result of these findings, we concluded that if a strong LMFBR program continues to be a national goal, the information we gathered clearly supported the view that the CRBR project should be completed as originally planned.

DOE's overall comment on this report was that GAO had not done an adequate analysis and presented a view advocating the early commercialization of the LMFBR technology. In rebutting this comment we pointed out that the purpose of this report was to analyze the Carter administration's basis for wanting to terminate the CRBR project. We emphasized in this report the following issue: "In light of the administration's and Congress' intention to continue a strong LMFBR program, should the Clinch River Project be built?"

"U.S. FAST BREEDER REACTOR PROGRAM NEEDS DIRECTION" (EMD-80-81, Sept. 22, 1980)

This 1980 report addressed the Carter Administration's decision to extend the proposed breeder reactor commercialization date to about 2020; and its efforts to (1) terminate the CRBR project, (2) refocus the LMFBR program on basic research and development, and (3) complete a conceptual design study for a large breeder facility but defer a decision to build that facility.

The report examined the management and focus of the entire fast breeder program as modified. In general, we found that:

--The Carter administration's strategy would not necessarily enable this country to achieve its non-proliferation goals.

--The projections of the availability of uranium were uncertain.

--Unanticipated events, such as the loss of Persian Gulf oil or future constraints on domestic coal supply, could increase the future demand for nuclear energy and the need for an early commercialization of breeder reactors.

--The ultimate economics of the LMFBR are difficult to accurately project.

--Without a demonstration plant, the breeder program as a whole lacked direction.

Accordingly, we recommended that if the Congress wished to maintain a nuclear option or if it wished to commit to nuclear power as a long-term energy source, the Congress should require DOE to demonstrate the viability of the LMFBR technology by mandating the construction of a breeder reactor facility. In making this recommendation, however, we emphasized that we were not necessarily advocating the completion of the CRBR project as the only means of moving the program forward.

We concluded that the imposition of a plant commitment on DOE would help foster a more appropriate U.S. breeder reactor research, development, and demonstration posture. We also suggested that, as part of this mandate, the Congress may wish to make it clear that it is not adopting a policy that would encourage premature commercial breeder deployment in this Country.

On the other hand, we also concluded that if the Congress cannot reach a resolution on whether to preserve the breeder option, or if it does not wish to do so, the Congress should consider terminating the breeder program.

In general DOE agreed that for effective management and resource utilization, a central organizing principle and a schedule were desirable for the program. Moreover, DOE recognized that, at that time, there was no national policy guidance on whether or when breeder reactors would need to be deployed. DOE stated that it had developed a rational approach for the development of the technology, should a national policy dictate that deployment of breeders was required.

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In summary, our past work has generally supported the view that a strong LMFBR program is needed <u>if nuclear fission is to be a long-term energy source</u>. Further, these reports supported the need to build a demonstration plant such as the CRBR project as the next logical step in the research and development process to obtain basic information on the performance, reliability, maintainability, and licensability of the breeder concept in a utility environment.

CHAPTER 3

A CURRENT PERSPECTIVE ON NUCLEAR POWER FROM WHICH TO JUDGE THE PACE AND DIRECTION OF THE LMFBR PROGRAM

Since our previous work on the LMFBR program and the CRBR project, DOE projections of the use of nuclear power as an energy source in the Nation have continued to decline. For example, DOE's projections on nuclear power growth have dropped by about 25 percent since our 1980 report. The decline in the expected use of nuclear power is further evidenced by nuclear power plant cancellations and delays and by lack of orders for new plants.

Many utility and industry officials believe this declining trend will turn around and that ultimately the Nation will again turn to nuclear power. They point out, for example, that an energy crisis--such as those experienced in the 1970s--could reverse the fortunes of the nuclear industry. While a sharp reversal in nuclear power's fortunes could occur, we believe it unlikely to occur soon or with great speed. First, it is possible that additional cancellations of plants now on order will exceed new orders in the 1980s. Second, if and when utilities begin to order new nuclear power plants, current experience indicates that it will likely take from 12 to 14 years to bring these plants on line.

On the other hand, we recognize that there will always be an element of uncertainty associated with making projections far into the future. In addition, as we have pointed out in previous reports, the LMFBR program is a research and development program designed to provide information essential to determining whether or not the Federal Government should permit commercial deployment of breeder reactors and related fuel cycle technologies. Viewed from this perspective, decisions on the pace and direction of the program need not be based solely on estimates of future commercial deployment time frames.

Against this backdrop we examined our previous positions on the LMFBR program and the CRBR project in terms of three questions which affect the appropriate pace and direction of the LMFBR research and development program and the role of the CRBR project in the program. These questions and their answers, based on the latest available data, are:

--How long can domestic uranium supplies fuel the light water reactor nuclear industry? Available domestic uranium supplies appear adequate to fuel conventional light water reactors well past the year 2020, which is as far as DOE makes such projections.

--When will breeder reactors be economically competitive with light water reactors? The latest DOE data shows that breeders may not be economical until after the year 2025.

--Is the CRBR project still an important and necessary step in developing the breeder option? A CRBR-type project is still an important step in developing the LMFBR option.

The following sections discuss these matters in detail.

A CURRENT PERSPECTIVE ON NUCLEAR POWER AS AN ENERGY SOURCE IN THIS COUNTRY

Since the mid-1970s, 61 domestic nuclear power plant projects have been canceled and still others have been stretched out for several years. Furthermore, only 6 plants have been ordered since 1974 and none since 1978. Low electric power demand growth rates and a generally poor utility industry financial posture has largely contributed to this condition. It is unlikely, we believe, that the present outlook for the Nation's nuclear power industry, as reflected by cancellations and delays, will be reversed unless and until conditions affecting the electric utility industry change, key problems facing nuclear power are successfully resolved, or unforeseen events otherwise necessitate a rapid return to nuclear power.

In December 1980, we reported that utilities were canceling and/or delaying completion of both nuclear and other types of electrical generating plants primarily because of lower rates of increases in electricity demand, financial difficulties, and to a lesser extent, regulatory problems at both the Federal and State levels. 1/ These problems, we found, were particularly impacting nuclear power plants because of the large capital investments required to construct these plants.

Despite these cancellations and deferrals, however, nuclear power continues to grow in terms of its share of U.S. electrical energy production. In April 1979, nuclear power plants represented about 9 percent of installed generating capacity. Subsequent completion of additional plants has increased nuclear power's share of U.S. electrical energy capacity to about 13 percent, according to the National Electric Reliability Council.

1/"Electric Powerplant Cancellations and Delays," EMD-81-25, Dec. 8, 1980.

The Council also expects that by 1990 nuclear power will provide about 25 percent of all U.S. electricity, second only to the approximate 53 percent contribution of coal.

Problems more peculiar to the nuclear industry have also contributed to nuclear power plant cancellations, the absence of new plant orders, and to declining public confidence in this energy technology. Major problem areas, some of which are long-standing and others which are relatively new, include

--disposal of nuclear wastes and decommissioning of nuclear power plants which have reached the end of their useful lives,

--the capabilities of utilities to properly construct and safely operate nuclear power plants, and

--the financial impacts of major accidents or equipment failures on utilities and their ratepayers.

The safe and environmentally sound disposal of radioactive wastes produced by nuclear power plants, particularly the spent nuclear fuel, has been a longstanding problem with nuclear power. While there has been progress in this area--for example, the Senate recently passed a comprehensive nuclear waste management bill which is now under consideration in the House--much more is yet to be accomplished. It is still unclear whether spent fuel from light water reactors will be disposed of as waste, or if the fuel will be reprocessed to extract the unused fissionable uranium and the plutonium for future use with disposal of the waste from reprocessing. Where, in what chemical form, and at what cost spent fuel or reprocessed waste will be disposed of is also a highly volatile issue and is thus still uncertain.

Similarly, the technical steps and related costs of decommissioning nuclear power plants once they reach the end of their useful lives are uncertain. To date, only a few small nuclear power plants constructed in the early years of the Nation's nuclear power program have been decommissioned. We recently addressed this issue in a report recommending an aggressive and unified Federal decommissioning program, including the establishment of a national decommissioning strategy. 1/

Regarding nuclear safety, the accident at the Three Mile Island unit 2 nuclear power plant in March 1979 focused attention on the safety of nuclear power plants in general, and more specifically, on the technical and management capabilities of utilities to properly construct and safely operate these plants.

1/"Cleaning up Nuclear Facilities--An Aggressive and Unified Federal Program is Needed," GAO/EMD-82-40, May 25, 1982.

Since then, problems have continued at Three Mile Island and major construction quality control problems have been identified at a number of nuclear power plants, such as the Diablo Canyon nuclear plant in California.

Utility difficulties in managing the construction of their nuclear power plants have affected costs as well as confidence in the quality of plant construction. The price tag on many individual nuclear power plants recently completed and under construction is over $2 billion.

Finally, in the aftermath of the Three Mile Island accident, and nuclear power plant steam generator technical problems surfacing in recent years, major questions have been raised concerning the financial impacts of major accidents or equipment failures. These questions are of concern not only to utilities, their rate commissions, and their ratepayers, but also the financial community which must underwrite construction of new power plants.

Utility and industry officials involved in nuclear power whom we contacted generally felt the problems facing the nuclear industry can be solved. They point out that other sources of electrical generation also have significant problems. In particular, they point to the actual and potential environmental hazards associated with burning coal--in contrast with coal, nuclear power does not produce carbon dioxide. These officials also stressed that nuclear power is a domestic energy source which can help alleviate our reliance on foreign oil. Thus, they believe nuclear power will continue to grow in this Nation's energy future.

SUFFICIENT URANIUM IS APPARENTLY AVAILABLE TO SUPPLY DOE PROJECTIONS OF NUCLEAR POWER GROWTH WELL PAST THE YEAR 2020

How long natural uranium will be available at reasonable prices to meet the needs of the current light water reactor industry is one of the key factors determining the timing and need for breeders to extend the use of nuclear power. Answers to this question will largely depend upon how much one believes nuclear power will grow, and the amount of uranium supplies available. Over the past years there has been considerable debate over the future and/or uncertain growth of nuclear power as well as uranium supplies that are available. Relying heavily on DOE data, our review showed that projections of nuclear power growth have dropped dramatically since the beginning of the LMFBR program and CRBR project. As a result, our domestic supplies are apparently sufficient to fuel conventional light water reactors well past 2020.

Projections of nuclear power growth have dropped dramatically

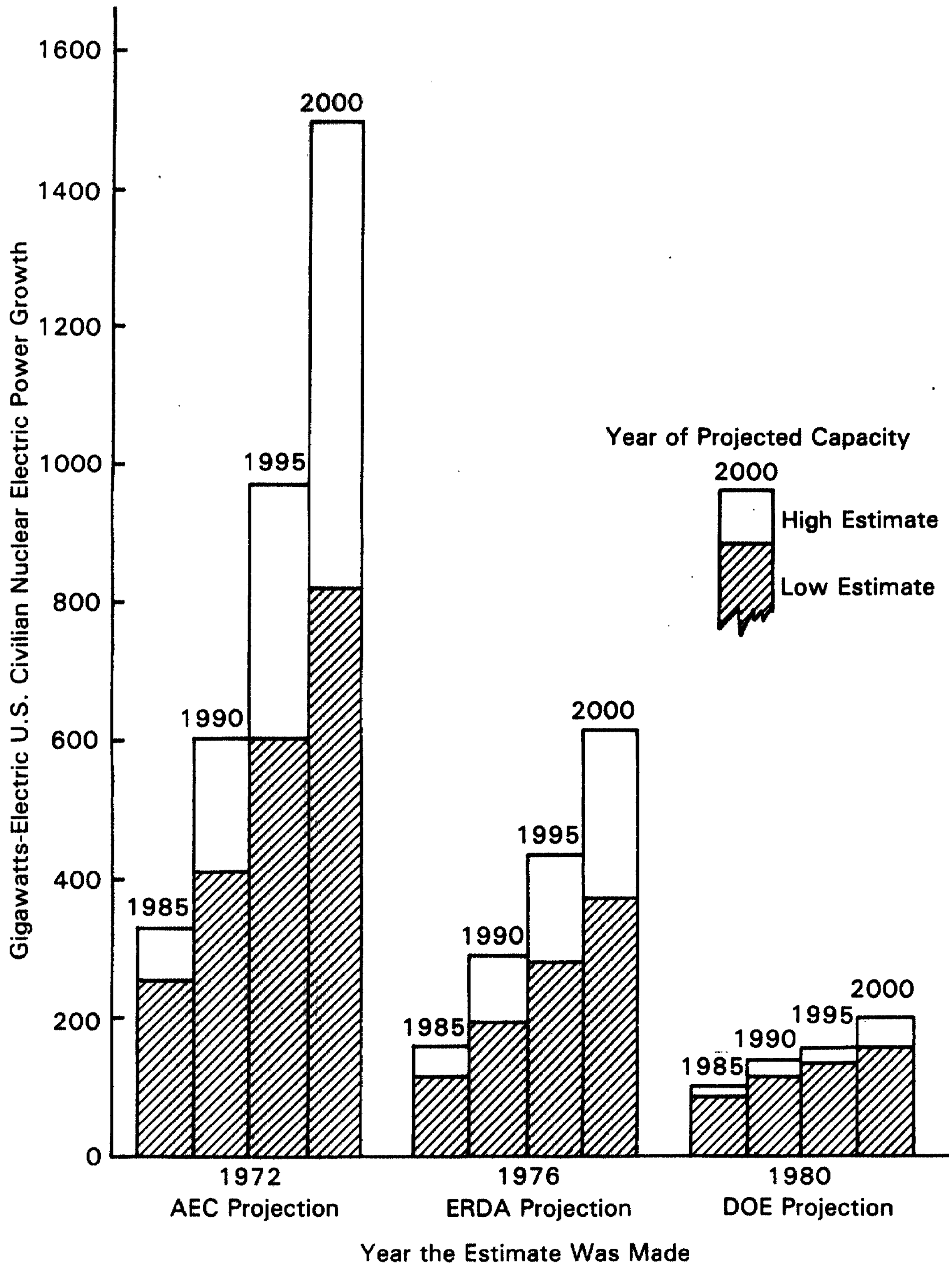
Government projections of the use of nuclear power have been dropping over the years. In the early 1970s, after the LMFBR program had been designated one of the Nation's highest priority energy research and development programs, electrical growth rate was high, and nuclear power was seen as a major energy source to meet this increased demand. For example, in 1972 AEC projected that 885 to 1,500 gigawatts of nuclear power generating capacity would be commercially deployed by the year 2000. However, over the past 10 years the projected growth of nuclear power has diminished greatly. The chart on page 17 highlights these changes in Government estimates from 1972 to 1980.

Overall, the chart shows over an 80 percent decline in DOE's projections of nuclear power use from 1972 to 1980. DOE's 1982 projections show an even further decline in the growth of nuclear power than highlighted on the chart. Estimates by DOE's Energy Information Administration show that it expects 145 to 185 gigawatts of nuclear power to be commercially deployed by the year 2000 1/--a drop from the 160 to 200 gigawatts cited in DOE's 1980 estimate. Next year's projections may even be lower due to cancellations in the planned deployments of nuclear power plants. In this regard, testimony by the Assistant Secretary for Nuclear Energy before the Subcommittee on Energy and Water Development, House Committee on Appropriations, on May 26, 1982, indicates that DOE projections on nuclear power deployment have further eroded.

As discussed previously, a number of factors have been responsible for this change. The primary reason has been the drop in the growth of electric power demand over the years and generally poor utility industry financial posture. Other important reasons include the utilities' financial condition, questions about nuclear safety, uncertainty over the economics of nuclear power, and the controversy over how best to dispose of nuclear waste. Utility and nuclear industry officials, while acknowledging that the nuclear industry's fortunes have been declining, believe it will reverse and nuclear power will again be expected to play a major role in supplying the Nation's energy. These officials point out that nuclear power continues to grow as a percentage of total electric power, and they expect this growth rate to accelerate in future years.

1/The low nuclear projection, as cited in DOE's Annual Report to the Congress, dated Feb. 1982, assumes a Gross National Product (GNP) growth rate of 1.5 percent per year while the high nuclear projection assumes a GNP growth rate of 2.5 percent per year.

Projections of Nuclear Generating Capacity 1985 to 2000



Domestic uranium resources now appear able to fuel the nuclear industry well past 2020

Since the beginning of the nuclear power industry there has been concern about the amount of uranium available to meet the needs of the industry. The Federal Government, in particular, has always been interested in using this resource more efficiently. To better assess the extent of the U.S. resource base, the United States initiated the National Uranium Resource Evaluation program in 1974. The goals of this program have been to assess and expand the nuclear fuel resource base of the United States, reduce uncertainties about the extent, availability, and economics of domestic nuclear fuel resources, and make such information available to industry. Over the years, the overall dimensions of domestic uranium supplies and the Nation's production capabilities have become better quantified. The following table shows the program's estimates of natural uranium reserves and potential resources as of October 1980. As of April 1982, DOE officials were in the process of revising this data. 1/

	Amount of natural uranium by forward cost (note a) category (note b)		
	$30/pound	$50/pound	$100/pound
	(thousands of tons)		
Reserves	645	936	1,122
Potential Resources			
Probable	885	1,426	2,080
Possible	346	641	1,005
Speculative	311	482	696
Total	2,187	3,485	4,903

a/Forward cost includes costs of power, labor, materials, royalties, payroll and production taxes, insurance, and applicable general and administrative cost in developing and operating a mine and building and operating a uranium mill in order to extract uranium. It does not include profit.

b/Higher cost category includes all lower cost material.

Additional uranium resources not included in the previous table include over 150,000 tons of natural uranium stockpiled by the

1/On May 27, 1982, DOE released its revised uranium reserves estimate. This data shows domestic reserves to be 894,000 tons in the $100/pound or less forward cost category. DOE has not yet released revised estimates for the potential resources categories.

Government or private industry. In addition, there are estimated to be millions of tons of low-grade uranium ore. This low-grade ore, however, is generally believed to have a forward cost much greater than $100 per pound and, according to DOE officials, may not be economically recoverable.

There has always been some debate as to what extent these various cost figures and potential resource categories should be used in planning the scope and pace of the U.S. nuclear energy development program. We pointed out in a previous report how different research groups have interpreted the data differently depending on which costs and reserve categories they felt were reasonable. DOE, in its May 1982 Final Environmental Impact Statement on the LMFBR program, stated that a uranium resource estimate in the 2 to 3 million ton range was a prudent assumption for planning purposes.

Although we did not attempt to verify DOE's estimate, the use of a 2 to 3 million ton uranium resource estimate is probably conservative. There should be at least that much available in view of the total amount (3.5 to 4.9 million tons in the $50 to $100 per pound range) cited in the table, the amount inventoried, and the amount of low-grade ore available. 1/ Furthermore, the 2 to 3 million ton resource estimate does not consider international uranium reserves which could be imported from major uranium producing countries, such as Australia or Canada, over the next few decades. On the other hand, the estimate does not consider potential exports of U.S. produced uranium.

How long domestic uranium will be available to fuel the current nuclear industry is, from strictly a resource standpoint, the key to when breeders are needed. In January 1975, ERDA issued a report which examined the need for and timing of breeders. This study found that uranium reserves and potential uranium resources would permit building conventional reactors until around the end of the century. Thus, the study concluded that having a commercial breeder available prior to the year 2000 would be prudent. The slowdown in the growth of commercial nuclear power, however, has changed this assessment and, thus, has pushed further into future when a breeder is likely to be needed from a resource standpoint. DOE's latest projections, for example, are that 220 to 355 gigawatts of nuclear power will be commercially deployed by the year 2020. 2/ The previous ERDA study projected deployment of this magnitude prior to 1990.

1/DOE information also indicates a 95 percent confidence in the existence of at least 3.8 million tons of uranium at a forward cost of $100 or less.

2/These are DOE's Energy Information Administration's figures which also estimate 145 to 185 gigawatts nuclear being deployed in the year 2000. DOE does not project commercial deployment of nuclear power plants beyond 2020.

This dramatic downturn in nuclear power growth projections extends the availability of domestic uranium resources. To determine the date that these resources are likely to be depleted, we asked DOE's enrichment operation to estimate the amount of natural uranium required to meet DOE's latest projected demand. Accordingly, DOE projected that 1.3 to 1.7 million tons of natural uranium will be needed through 2020. 1/ When comparing this data with DOE's prudent planning estimate of 2 to 3 million tons of uranium resources, it appears that there are sufficient uranium supplies to fuel light water reactors well past 2020.

This analysis does not take into account the possibility of adopting technological processes for more efficiently utilizing uranium fuel which could further extend domestic uranium resources. These processes include using more sophisticated uranium mills to recover more natural uranium, reprocessing, advanced enrichment processes to extract a higher percentage of fissionable material from natural uranium, and developing more efficient reactors. The adoption of some or all of these technological processes could possibly extend uranium resources by decades. For example, DOE data shows reprocessing could reduce uranium requirements for light water reactors by about 30 percent. 2/ Thus, with reprocessing, DOE's estimate of the amount of natural uranium to meet demand in 2020 could be reduced to .9 to 1.2 million tons and could delay the date by which commercial LMFBRs will be needed by as much as 10 years.

Officials of DOE's breeder program agree that the slowdown in nuclear energy growth has extended the estimated date when domestic uranium resources will be depleted. They point out, however, that because of numerous uncertainties surrounding the future use of nuclear power and uranium resource utilization--for example, how much uranium we export or import in the next 20 to 30 years--domestic uranium resources could be depleted much sooner. We recognize that a number of possible events could result in using domestic uranium resources sooner than expected. Still, DOE's own latest estimates on uranium availability and nuclear power growth show sufficient domestic uranium supplies to fuel the nuclear industry well beyond the year 2020.

1/DOE officials, in commenting on this report, told us that this would translate into 1.3 to 2.1 million tons of natural uranium that would have to be committed to light water reactors by 2020 to fuel them over their lifetime.

2/This includes using both plutonium and residual uranium as fuel for light water reactors.

DOE DATA SHOWS BREEDERS MAY NOT BE ECONOMICAL UNTIL AFTER 2025

The economic promise of the LMFBR is that it could supply the Nation with electricity--at a competitive economical cost--some time in the future. Since the LMFBR is generally considered the next generation of nuclear powerplants, most studies compare the LMFBR against conventional light water reactors. These studies generally consider LMFBRs to be more expensive to build (capital costs) than light water reactors, but LMFBR fuel cycle costs are expected to be lower.

The LMFBR capital cost has been the subject of considerable controversy. DOE and non-government studies examining this question have estimated that a commercial LMFBR could cost anywhere from 1.1 to 1.75 times more than light water reactors. The latest DOE estimate as of January 1981, shows an LMFBR to be 1.38 times more expensive than a light water reactor. DOE officials point out, however, that this cost differential would be associated with the first few commercial LMFBR plants. Eventually, DOE officials expect that LMFBR capital cost would drop to no more than 1.2 times more expensive than a light water reactor. DOE officials also point out that there are no inherent technical reasons why the breeders should cost more to build than a light water reactor.

Assumptions about capital costs have a significant impact on the relative economic position of LMFBRs. To illustrate capital cost impacts, we used a DOE computer program to price out the cost of generating electricity from an LMFBR versus light water reactor under different capital cost assumptions. 1/ The purpose of this table is to show the relative difference between the cost of electricity generated from each.

Capital cost differential	1981 cost of electricity generated (mills/kilowatt hour) (note a)	
	LMFBR	LWR
1.10	31.0	31.7
1.20	32.5	31.7
1.38	35.3	31.7
1.75	41.0	31.7

a/One mill is a tenth of a cent.

As the previous table shows, the capital cost of the LMFBR can greatly influence the economic competitiveness of the LMFBR with light water reactors.

1/In this analysis, we kept the selling price of uranium constant at $125 per pound.

Fuel cycle cost is the next most significant cost factor. The light water reactor fuel cycle cost includes such items as mining and milling uranium, converting, enriching, and fabricating uranium into fuel rods, and disposing of this fuel. The LMFBR fuel cycle is generally considered more economical. While it includes some of the same steps, such as fabricating fuel rods, it does not require the mining and milling of uranium or enriching uranium. Furthermore, the breeder can produce more than enough plutonium to refuel itself. If the LMFBR is to be economically competitive with a light water reactor, the LMFBR fuel cycle cost must be sufficiently more economical than a light water reactor to offset the expected higher LMFBR capital cost.

According to DOE officials, the most critical cost factor in a fuel cycle cost analysis is the selling price of uranium. In this regard, DOE officials stated that when natural uranium becomes scarce and the price is driven up, a light water reactor will become more expensive to operate and thus make breeders more competitive. However, DOE data on how the cost of electricity from a light water reactor is affected by the selling price of natural uranium shows that electricity costs are not as sensitive to increases in the price of uranium for light water reactors as they are to higher capital costs of breeder reactors. For example, increasing the relative capital cost of a breeder reactor to a light water reactor from 1.20 to 1.75--a relative increase of about 46 percent--would increase the 1981 estimated cost of electricity generated by a breeder reactor from 32.5 to 41--an increase of 8.5--mills per kilowatt-hour. On the other hand, DOE data shows that the price of natural uranium would have to at least triple--from $50 to $150 per pound 1/, or a 200 percent increase--in order to get the same 8.5 mills increase. Thus, while the price of uranium is an important cost factor, it does not appear to be as sensitive a factor as capital cost in comparing the economics of the LMFBR and a light water reactor.

Nevertheless, projections on the time when commercial LMFBRs may become economically competitive with light water reactors vary greatly depending on the assumptions that are made about how much uranium resources will be available, how much uranium will cost, how efficiently it is utilized, how much LMFBR construction costs prove to be, and the growth rate of nuclear power. Although there is always uncertainty associated with such assumptions, over the years these assumptions have been changing and delaying the time an LMFBR will likely be economical. In the early and mid-1970s, many Government studies showed LMFBRs would be competitive around the year 2000. Later DOE studies have pushed this date back considerably. For example, in September 1978, DOE prepared a nuclear strategy paper to support its upcoming annual budget. In this paper, DOE prepared a wide variety of estimates (in the form of tables) of

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1/1981 spot market prices for uranium less than $40 per pound.

when an LMFBR would be economically competitive depending on such key factors as capital cost for an LMFBR, selling price of natural uranium, and installed nuclear generating capacity in the year 2000. Using the latest available DOE data and applying it to these tables shows an LMFBR to be competitive with light water reactors some time after 2025. The most recent DOE study we could identify was dated December 1981 and titled "Analysis of Alternative FBR Development Strategies." It shows that a commercial breeder would most likely be economical if it came on-line some time between 2025 to 2035.

Utility and nuclear industry officials we contacted, as well as some DOE breeder program officials, stressed the uncertainties associated with making any projections on the economic time frame of breeders. They pointed out, for example, that uranium prices could rise much faster than anticipated and thus make breeder reactors economical sooner than 2025. They also generally believe that without construction experience, LMFBR capital costs are highly speculative. Some nuclear industry and government officials believe only after "hands on" construction experience with breeder reactors will industry and DOE get a good picture of what a commercial-size plant will likely cost. Before such time as actual construction costs are available, these officials tend to view economic studies as merely academic exercises.

A CRBR-TYPE PROJECT IS STILL AN IMPORTANT STEP IN DEVELOPING THE LMFBR OPTION

In 1970 the Congress authorized AEC to enter into a cooperative arrangement with private industry to build and operate the CRBR. The project's size--about 375 megawatts-electric--was selected as a prudent step toward the eventual development of a commercial-size (1,000 megawatts or greater) LMFBR power plant. Because the CRBR is the next logical step in the LMFBR program, and because of its cost and size, it is the present focal point of DOE's LMFBR program. The CRBR's primary objectives are to

--demonstrate the safe, clean, and reliable operation of an LMFBR resembling a commercial-size plant while showing a high availability factor for power production in a utility environment;

--serve as the focal point for the development of systems and components;

--develop industrial and utility capabilities to design, construct, and operate LMFBRs; and

--demonstrate the licensability of LMFBRs.

According to DOE, constructing and operating an LMFBR demonstration plant is the best means by which these objectives can be realized. AEC originally considered other approaches to achieving these same objectives, including trying to encourage industry to undertake the demonstration of LMFBR technology on its own, relying on foreign experience to demonstrate the concept, and purchasing foreign LMFBR technology and adapting it to the prevailing U.S. regulatory requirements. According to AEC, however, none of the alternatives met the objectives satisfactorily.

In prior reports, we have examined in depth the technical importance of the CRBR project. In these reports, after interviewing a wide range of knowledgeable industry, Government, and private individuals on this subject, we found that the intermediate size of the CRBR project is a prudent step in making the LMFBR technology a viable and timely option for future nuclear energy supply. The size represents a logical step in the scaleup of LMFBR reactor facilities. Furthermore, we learned from industry officials and technicians involved in the fabrication and testing of LMFBR components that there is no reasonable substitute for testing components in an operating reactor environment. These same people also informed us that the most reliable way to fabricate and test these components was in progressively larger steps. The scaleup to a CRBR project size facility, in their judgment, represented the most reasonable step in this process. The April 1977 majority report of the LMFBR Steering Committee of ERDA also reflected these views. This was again reinforced in March 1979 in a report prepared by a DOE-sponsored study group headed by the Westinghouse Corporation. Finally, utilities and industry officials we contacted in the course of this review strongly supported building the CRBR as a critical step in developing the breeder option. In this regard, a March 1979 reassessment of U.S. breeder reactor policy by the Atomic Industrial Forum stated:

> "Completing the Clinch River as quickly as possible is the right choice, for many reasons. It will cost less and will involve less technical, economical, and political risk than any proposed alternative."

Building an intermediate size CRBR-type demonstration project is basically the same approach as that followed in developing foreign breeder programs. The LMFBR programs of the Soviet Union, France, the United Kingdom, and Japan all include intermediate size demonstration plants similar to the CRBR project. (See app. I.) This does not mean, however, that the CRBR project is the only means to demonstrate the technology. The important fact is that a demonstration plant along the size and scale of the CRBR project is an important research and development step. Once this step is completed the next logical step would be to follow it at some future time by a commercial size breeder reactor such as the proposed large development plant.

CHAPTER 4

LMFBR PROGRAM OPTIONS

Information important to decisions concerning the LMFBR program has changed substantially since the LMFBR program was first designated as one of this Nation's highest priority research and development programs in the early 1970s. As discussed in chapter 3, expectations of nuclear power as an energy source have been declining and DOE data now show that commercial LMFBRs may not be needed or economically competitive until well into the 21st century. These changed circumstances--in a time of budgetary restraint--have intensified the debate over the pace and direction of the LMFBR program in general and the CRBR project in particular.

There are many development courses open to LMFBR decisionmakers. Determining which is best is a dynamic process requiring judgments about the future course of nuclear power and continual reassessments of program goals against available information on such factors as uranium availability, LMFBR economics, and LMFBR technology risks. Obviously, there is much uncertainty inherent in projecting trends and/or events, such as future electricity and nuclear power growth, far into the future. Nevertheless, decisions must be made now based on the latest information and estimates of future events.

In this context there are three fundamental options open to LMFBR decisionmakers:

--continue the present program along the lines proposed by DOE in its May 1982 Final Environmental Impact Statement on the LMFBR program. This includes constructing the CRBR by about 1990, constructing a large development plant with substantial industry financial participation by the mid-1990s, thus permitting the first commercial plant decision a few years thereafter; or

--restructure the program to provide more time for developing the technology and/or spreading the construction and operation of demonstration plants over a longer period of time; or

--terminate the LMFBR program in its entirety.

This report does not consider the option pursued by the Carter Administration--canceling the CRBR project and building a larger demonstration plant sometime in the future. As discussed in chapter 3, we believe a CRBR-size demonstration project to be the next logical step in developing the LMFBR option.

The following sections discuss the aforementioned fundamental options, their tradeoffs, and some alternatives within them. This discussion centers primarily on the timing for constructing and operating LMFBR demonstration plants because of their importance to developing LMFBR technology. It does not purport to list or present all tradeoffs among them. Rather, the discussion of alternatives is intended to provide a perspective on the range of key options open to the Nation regarding the LMFBR program and the timing of demonstration projects within the program.

CONTINUE THE LMFBR PROGRAM ON DOE'S CURRENT SCHEDULE

Continuing DOE's present LMFBR program plan as set forth in its May 1982 Final Environmental Impact Statement on the LMFBR program would include (1) constructing the CRBR as soon as possible and operating it by about 1990, (2) constructing a large development plant with substantial industry financial participation and operating it by the mid-1990s, and (3) continuing the base technology program through 2000. Under this plan, the first utility decision to order a commercial plant could be made a few years after construction of the large development plant is completed. It should be noted that DOE's plan is contingent upon private sector financing of the major portion of the large development plant capital funding, and details of these financial arrangements are yet to be worked out.

As discussed in chapter 2, a number of our past reports have emphasized that, if the Nation wants to commit to nuclear power as a long-term energy option, it makes sense to move forward by building a demonstration plant. Building a CRBR-type demonstration plant now, followed by a larger plant, is probably the quickest way to gather essential information on the safety, environmental, and economic issues surrounding breeders. Continuing the present program provides the best assurance that breeders will be available when needed and provides the focus lacking in the LMFBR program over the past several years. In addition, DOE officials believe the present program would keep the Nation competitive with foreign LMFBR programs. They also believe it would represent a symbol to the nuclear industry that the Nation is making a commitment to the long-term future of nuclear power and would avoid losing the technical expertise industry has acquired since the program began. Utilities and industry officials involved in nuclear power echoed similar views in support of continuing the present development program on schedule. These officials stressed the importance of getting operational experience from a breeder reactor so that the future role of breeders could be better assured.

On the other hand, a decision to continue the present program must be measured against two tradeoffs. First, the breeder could be developed well before it is needed or economically competitive--that is, well before there is enough incentive for utilities to order breeder plants. Although there are always uncertainties associated with projections of future events, the steadily declining growth rate in deploying nuclear power plants has extended further into the future the time when commercial breeders are likely to be deployed by utilities. Some industry officials acknowledged that in view of the current situation surrounding nuclear power, it appears unlikely that any utility will order a breeder reactor as early as around the year 2000.

DOE officials recognize the present program could demonstrate the LMFBR technology sooner than needed by industry. They maintain, however, that the detrimental consequences of being too early are far outweighed by the consequences of being too late. While this may be so, it is also important to recognize that under DOE's present program timetable, DOE could develop a commercial size plant decades before it is economically competitive or is needed on the basis of uranium availability. In the interim between the time when an LMFBR plant is developed and when it is needed or becomes economical, it is unclear what the LMFBR program would focus on or how the industry infrastructure and expertise would be maintained.

The second tradeoff that must be considered in continuing the present course is the program's budgetary cost, particularly in the short term. In the fiscal year 1983 budget, DOE is requesting $523 million for the breeder program, including $253 million for the CRBR project. This is one of the highest priority energy research and development programs in DOE's budget. There is concern that this high priority might be misplaced, especially at a time of fiscal restraint. Debate on funding for CRBR in DOE's fiscal year 1982 budget centered on this issue and is expected to surface again during deliberations on the 1983 budget. Questions about this high priority were also raised by DOE's Energy Research Advisory Board in its November 1981 report on Federal energy research and development priorities. The Board stated that construction of a breeder reactor demonstration plant--specifically the CRBR--at this time is not an urgent priority and recommended that under current budget constraints, such a demonstration could be delayed until a future time.

DOE officials recognize that short-term budget savings could be achieved by delaying demonstration projects but point out that the total cost of the project could increase in future years due to inflation and other factors such as storing components.

RESTRUCTURE THE LMFBR PROGRAM ON THE PREMISE THAT BREEDERS MAY NOT BE COMMERCIALLY DEPLOYED UNTIL AT LEAST 2025

Restructuring the LMFBR program would recognize the continuing decline in the expected growth of nuclear power that has occurred over the last 10 years and continuing problems facing the nuclear industry. Basically, this option would center around timing demonstration projects on the premise that breeder reactors may not be commercially deployed until at least 2025. The tradeoffs associated with this option vary depending on how and to what extent the program is restructured. Moreover, in any consideration of restructuring the LMFBR program it important to focus on the specific objectives and purpose of a restructured program. Several illustrative ways to restructure the LMFBR program include:

--Complete the CRBR, delay the large development plant, and continue the base technology program.

--Defer both the CRBR and large development plant, but continue the base technology program.

--Stretch out or delay construction of the CRBR and/or large development plant and continue the base technology program.

Choosing any of these suboptions would, to a certain extent, slow the overall pace of the program and run the risks that (1) the LMFBR option may not be ready when the Nation needs it if circumstances change and demand for nuclear power grows faster than is currently anticipated, (2) foreign manufacturers will have the advantage of reaching the marketplace first, and (3) total research and development costs will be higher. Also, a slowed LMFBR program could be interpreted symbolically by the nuclear industry and utilities that the Federal Government is no longer committing to nuclear fission as a long-term energy source. As a result, industry may be reluctant to continue to commit its expertise and resources to a slowed down program. In this regard, a number of industry officials told us that if the Government restructured the program, they would probably rethink their role in the program.

DOE believes slowing the program will retard progress, diffuse and disperse the highly-trained manpower, cause the Nation to settle for an international status that is second best, and pose the threat of foreclosing the use of nuclear power in the United States. Finally, in commenting on our report DOE stated it is imperative to proceed with the LMFBR program and CRBR project on the current schedule. In DOE's view, slowing the program, if ultimately proven incorrect, would have serious national security implications. Industrial disruptions, constrained economic growth, and increased reliance on foreign supply can be expected, DOE said, if adequate economic supplies of energy are not available.

Complete the CRBR project and delay the large development plant

Under this suboption the program would not proceed directly to the construction of a large development plant beyond the CRBR. Such an option would allow more time for making decisions on when to build the larger plant, the most appropriate size and design for the plant, and financing arrangements. Furthermore, the timing of a large development plant could be more in line with current estimates of when breeder reactors are likely to be deployed. Choosing this option would also make maximum use of the funds that have been invested to date in the CRBR project. Some nuclear industry and government officials told us that there are advantages to deferring construction of the large development plant to a later time than planned by DOE. Specifically, they pointed out that if the large development plant is delayed and the CRBR is built on schedule, the operating experience gained from the CRBR could be better applied to the final detailed design of the large development plant. This could help to avoid possible problems of too rapid development of breeder technology. For example, some industry officials speculate that too rapid technology development and commercialization underlie the current problems in the light water reactor nuclear industry. They further point out that this operational experience could be critical in seriously looking at ways of reducing the capital cost associated with breeders--the key economic uncertainty affecting the potential deployment of commercial LMFBRs. According to these officials, meaningful research could be accomplished in the interim, especially in regard to reducing capital costs.

Budget savings would not accrue immediately under this approach. Additionally, this option, according to DOE, could lead to the erosion of the industry/utility/national laboratory infrastructure that will be needed for future LMFBR commercialization. In this respect, DOE officials believe that in the interim between the CRBR and the construction of a larger plant it may be difficult to focus the base technology program only on component development and testing.

Defer both demonstration projects

The major benefit of the second suboption--deferring both demonstration projects but keeping the base program going--would probably be budgetary savings, at least in the short-term, and an opportunity to reassess funding priorities. It would also allow decisionmakers time to assess whether utilities are likely to resume ordering new nuclear power plants and at what rate, and to reconsider the structure and pace of the entire LMFBR program based on this assessment. On the other hand, this option might increase total LMFBR program costs.

According to DOE officials, the disadvantages of this option would be significant. They maintain that, if circumstances currently affecting the growth of nuclear power change and demand increases, a commercial LMFBR might not be available when needed. In addition, DOE officials view demonstration plants as essential to any serious commitment to developing LMFBR technologies. They also point out that without operating plants there is no significant involvement of industrial suppliers in the LMFBR development program; and construction, start-up, operating, and licensing experience will be completely lacking. This could seriously disrupt the continuity of the current base program which would otherwise be looking to resolve problems in building a follow-on large development plant. Nuclear industry officials strongly emphasized the importance of demonstration projects in carrying out a meaningful research and development program. These concerns raise serious questions as to whether a base technology program could be technically and cost effective without the focus provided by one or more development plants.

Our 1980 report tended to support DOE's position on the need for focusing the LMFBR efforts. We said that the program at that time was in a state of disarray and lacked focus. We also said that, within the current program and assuming a long-term commitment to nuclear power, a demonstration plant was the best way to provide that focus. We recommended that, if the Congress wished to maintain a nuclear option or if it wished to commit to nuclear power as a long-term energy source, it should require DOE to construct a breeder reactor demonstration facility. We also recommended that the Congress consider terminating the breeder program if it cannot reach a resolution on whether to preserve the breeder option or it does not wish to preserve the option.

Stretch out or temporarily delay construction of the CRBR and large development plant

Under the third suboption, the schedule for constructing the CRBR project followed by the large development plant would be either stretched out or temporarily delayed in recognition of the current projections of the need for a commercial LMFBR. If delayed, the CRBR plant design--which is about 90 percent complete--would be completed but construction would not begin immediately. Several benefits of this option are similar to the previous option. Specifically, some of the immediate gains include reducing Federal funding for the LMFBR program in the earlier years, and more time to assess the general role of nuclear power and the specific role of breeder reactors in the Nation's energy future. Similar benefits would accrue if construction of the CRBR was stretched out. That is, construction could begin immediately but the CRBR would be built over a longer period of time.

In addition, choosing this suboption, whether the construction of the CRBR project was stretched out or temporarily delayed, would allow more time to test key components for the CRBR demonstration plant, thereby lowering the development risks associated with building the project. For example, steam generators are critical plant components which have caused problems in smaller breeders in this country as well as comparable units in foreign countries. In this respect, GAO recently issued a report "Revising the Clinch River Breeder Reactor Steam Generator Testing Program Can Reduce Risks" (GAO/EMD-82-75, May 25, 1982) which raised questions about DOE's testing program for steam generators and the possible need for additional development testing before these components are used in a demonstration plant. In this report we recommended that the Secretary of Energy evaluate the information presented in the report, as well as the risks assumed in not conducting more complete and thorough tests of the steam generator design, in deciding on how to proceed with the procurement of the CRBR steam generators. 1/

This option would also allow time for an immediate technical reassessment of the LMFBR program. Such a reassessment would allow DOE to examine new concepts, designs, and components that might, for example, lower the capital costs of an LMFBR--the key economic uncertainty affecting the potential deployment of commercial LMFBRs.

In addition to the risks discussed earlier associated with any slower approach, DOE officials believe that if the CRBR project is delayed, personnel and facilities engaged in plant and component design and fabrication will be lost by even a few years delay and that their retrieval will be difficult and expensive. DOE officials also point out that if construction of the CRBR is stretched out or deferred, total program costs due to inflation, storage of CRBR components, and other factors would increase. Finally, this suboption--while possibly reducing risks in the near term--may increase risks in the long term by squeezing the commercial deployment timetable and delaying the time meaningful operational data on breeder reactors could be obtained. According to industry and some government officials, the operating experience from an intermediate-size plant should be the firm basis for designing future plants--especially lower cost breeder plants. Hence, some industry as well as government officials agree that if the program must be slowed, it should be slowed after construction of an intermediate-size plant.

TERMINATE THE LMFBR PROGRAM

The most obvious benefit of abandoning the LMFBR program is that it would free limited Government funds for other energy and non-energy programs or for reducing Federal expenditures. The major tradeoff is that, by abandoning the LMFBR program and the CRBR project, the Nation might be foreclosing on the long-term future of one of its major domestic energy options--nuclear fission. As a consequence, the country might have to depend more heavily on foreign oil, coal, or yet undeveloped alternative energy technologies, such as fusion or solar energy, to meet the country's electric demand.

Oil, whether it is domestic or foreign, is not a long-term source of energy. Further, relying on foreign oil has obvious economic and political costs which should be avoided. Coal, on the other hand, is a long-term source of energy which is in abundant supply in this country. However, unlike nuclear power--where the hazards and environmental consequences have been recognized and regulated from the beginning--some of the environmental

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1/Subsequently, on July 2, 1982, DOE awarded a $34 million fixed price contract to a division of Westinghouse Corporation for fabrication of 10 CRBR steam generators.

hazards associated with coal use have only recently been identified and controlled, while other potential hazards, such as acid rain and the possible buildup of carbon dioxide in the atmosphere, are still the subject of a great deal of controversy and have not been studied in great depth. If these hazards are found to be unacceptably harmful to the environment, the use of coal as a long-term fuel source for generating electricity would be greatly curtailed.

In that event, foreclosing the long-term nuclear fission option would place increased pressure on developing other alternative long-term energy technologies such as fusion or solar energy. Most of these technologies currently are only in the basic research stage or are not now economically competitive. To rely heavily that research efforts in these areas will be successful would assume a substantial risk. Utilities and nuclear officials we contacted generally echoed these views.

When one considers both the electricity needs of the future and the alternatives for producing this electricity, at the present time it appears that coal and nuclear power are the only supply sources which are adequate to satisfy the potential need. As noted earlier, although nuclear plant orders have stopped and many plants have been canceled, nuclear power continues to grow in terms of its contribution to total U.S. electrical energy production. Furthermore, there is uncertainty on the potential for heavy reliance on coal to satisfy the potential need for electricity because of growing concern over its environmental effects.

A final tradeoff to be considered in terminating the LMFBR program is the funds that have already been spent on the program. About $6 billion has been spent and, if the program is terminated, it seems reasonable that much of this cost would be wasted.

CHAPTER 5

OBSERVATIONS, MATTERS FOR CONSIDERATION BY THE CONGRESS, AND AGENCY COMMENTS

For some years now the LMFBR research and development program in general and the CRBR demonstration project in particular have been surrounded by controversy. This controversy has led to shifts in program direction and efforts to defer or cancel the CRBR demonstration plant. In this environment, it has been difficult for program officials to manage the program and to maintain a focused development effort. Proponents and opponents alike have used the same basic information to argue both sides of the issue. Chapter 4 of the report describes the tradeoffs involved in choosing among the fundamental options now available to congressional LMFBR decisionmakers. Choosing any of these options will require judgments regarding future events 20 years and more away. Thus there will always be an element of uncertainty inherent in making any of these decisions. Furthermore, decisions on the future course of the LMFBR program require policy judgments by the Congress on such things as

--what role nuclear power should play in meeting this Nation's electrical energy needs,

--the extent to which this Country may want to rely on foreign technology, and

--the relative budget priority of the LMFBR program versus other energy and non-energy programs.

In the final analysis, decisions must be made amid the inherent uncertainties associated with predicting future events as well as unquantifiable policy judgments. At this point in time, we believe several points concerning the LMFBR program should be carefully weighed in deciding the future pace and direction of the program.

First, the LMFBR program should be recognized for what it is--a research and development program intended to provide information essential to determining if the Federal Government should permit commercial deployment of the LMFBR technology.

Second, there has been a continual erosion in the anticipated growth of nuclear power over the last 10 years. In this regard, DOE's projections have dropped over 80 percent since the Atomic Energy Commission's projections of the early 1970s. Even since our last major report on the LMFBR program in 1980, DOE's projections have dropped 25 percent. Furthermore, there are indications that this downward trend has not bottomed out and future projections may be even lower. At this point in time

DOE's latest projections on nuclear power deployments and relatively conservative estimates of domestic uranium supplies show that an LMFBR will probably not be needed until well past the year 2020--the furthest that DOE now makes nuclear power projections. These projections do not consider possible advances that may occur in mining and using uranium, or the effect of imports and exports of uranium over this time period.

Third, the most recent DOE study shows that LMFBRs may not be economically competitive with light water reactors until sometime after the year 2025. To be competitive before that time, the research and development program must bring projected LMFBR capital costs down or the price of uranium must increase substantially.

Fourth, a CRBR-type demonstration plant is the next logical step in the present LMFBR research and development program. If the LMFBR is to be commercialized, such a plant will eventually be needed to gain information on breeder reactor licensability, maintainability, economics, and safety. In addition, our past work has shown that an intermediate-size demonstration plant such as CRBR represents a prudent extrapolation in size of breeder reactor technology.

Fifth, terminating the LMFBR program or the CRBR project in favor of other long-term nuclear fission options will not reduce proliferation risks. Numerous studies have shown that all long-term nuclear fission options present proliferation problems and that no one option has any particular non-proliferation advantages over the other.

Finally, the Nation has already made a considerable investment in developing LMFBR technology. About $6 billion has been spent on the LMFBR program, including a little over $1 billion on the CRBR project. If the LMFBR program were terminated, much of this "sunk" cost probably would be wasted even if the program was restarted at some future date.

In view of these facts, there are three fundamental options for the Congress to consider in making decisions on the LMFBR program and the CRBR project--continuing the program at its current pace and direction, restructuring the program, and terminating the program.

In our view, continuing the program along the lines proposed by DOE implies a commitment to nuclear fission as a long-term energy source. In addition, it may imply (1) a judgment that the current state of nuclear power is temporary and will be reversed and (2) an unwillingness to accept the risk that the technology will not be available if and when needed.

Conversely, restructuring the program implies a willingness to slow the program in light of current trends in nuclear power use while still maintaining a commitment to nuclear power as a long-term energy source. In other words, it keeps the LMFBR option open. The extent to which that option is kept open depends upon the approach followed in restructuring the program. Illustrative ways to restructure the program include (1) completing the CRBR project as DOE plans but delaying construction of a larger devel opment plant, (2) deferring both the CRBR project and the large development plant, and (3) stretching out or temporarily delaying construction of the CRBR project and/or the large development plant. If this option is chosen, however, the Congress should assure itself that the program is redesigned and restructured in a way that maintains a focused effort. Exactly what short-term budget savings may be available will depend on the approach used in restructuring the program.

Finally, terminating the program implies a willingness to foreclose on the long-term future of a major energy option--nuclear fission--thereby relying on other alternative energy technologies such as fusion and solar energy, together with coal, to meet future electrical demand. It also implies a possible willingness to import breeder technology from foreign countries if these alternative technologies are not developed in time and/or if environmental problems with coal necessitate curtailing its use as a fuel for generating electric power.

We still believe, as we have in the past, that decisions regarding the LMFBR program revolve around the question of whether this country wants to maintain a nuclear option and wants to commit to nuclear power as a long-term energy source. Clearly, in the past several years, nuclear power's momentum has slowed substantially and the time horizon for when commercial LMFBRs will be needed has been pushed further into the future. Nevertheless, nuclear power still remains an important domestic electrical energy option and, depending on future events, could become even more important.

Therefore, while the Congress has three fundamental options available to it--continuing, restructuring, or terminating the LMFBR program--in our opinion the uncertainty inherent in projecting far into the future argues against the termination option. Thus, we believe the prudent choices available to the Congress lie between continuing the LMFBR program on DOE's present course or restructuring the program with clearly defined and agreed upon program goals and objectives.

MATTERS FOR CONSIDERATION BY THE CONGRESS

Decisions about the future pace and direction of the overall LMFBR program and the CRBR project must take into consideration many factors which are not quantifiable. Furthermore, there is always an element of uncertainty in predicting future conditions and events. The decision requires judgments about such important things as the future growth of nuclear power and the role it should play in this Nation's long-term energy future, the relative budget priority this program should receive, and the extent to which we want to risk relying on foreign technology. In the final analysis, the Congress must make these judgments.

In making its judgments, however, the Congress should consider the information presented in this report together with other sources both within and outside of the Federal Government. Should the Congress decide to consider restructuring the program, it should request from DOE and others information on, among other things,

--the various options available for restructuring the LMFBR program and the tradeoffs associated with each option;

--required spending levels for each option;

--the extent to which additional testing of critical demonstration plant components can reduce developmental problems; and

--ways to refocus research efforts to emphasize reducing LMFBR capital costs.

DOE COMMENTS

DOE provided official comments on a draft of this report. We made changes in the report to reflect DOE's comments and also the views we obtained from utility and nuclear industry representatives and nuclear energy experts.

DOE stressed the importance of proceeding with the LMFBR program and the CRBR project on DOE's current schedule. Anything less, according to DOE, could have serious national security implications. DOE said that industrial disruptions, constrained economic growth, and increased reliance on foreign supply can be expected if adequate economic supplies of energy are not available. DOE also stated that failure to pursue the LMFBR program as it plans would have the effect of diverting and dispersing the program's highly trained manpower, thus making it difficult if not impossible to redevelop a high level of expertise should a decision be made to again expedite LMFBR development and commercialization.

The full text of DOE's comments is in appendix III beginning on page 40.

HIGHLIGHTS OF FOREIGN BREEDER PROGRAMS

The United States is only one of several countries actively engaged in LMFBR programs. The following table summarizes foreign LMFBR programs.

As can be noted, there are currently six experimental LMFBRs and three demonstration LMFBRs operating outside the United States.

Country	Name	Power	Type	Operating date
France	Rapsodie	40 MWt	E	1967
France	Phenix	250 MWe	D	1973
France	Super-phenix	1,200 MWe	C	1983
Germany	KNK II	21 MWe	E	1977
Germany	SNR-300	300 MWe	D	1986
Germany	SNR-2	1,300 MWe	C	1990s
Italy	PEC	118 MWt	E	1983
Japan	Joyo	100 MWe	E	1977
Japan	Monju	300 MWe	D	1987
United Kingdom	Dounreay (DER)	15 MWe	E	1963
United Kingdom	PFR	250 MWe	D	1974
United Kingdom	CDFR	1,300 MWe	C	1990s
U.S.S.R.	BR-10	10 MWt	E	1956
U.S.S.R.	BOR-60	12 MWe	E	1963
U.S.S.R.	BN-350	350 MWe	D	1973
U.S.S.R.	BN-600	600 MWe	D	1980
U.S.S.R.	BN-800	800 MWe	C	1990

MWt - megawatts thermal (heat).
MWe - megawatts electric (power).
Approximately 3 MWt are required for each MWe produced.

E - Experimental.
D - Demonstration.
C - Commercial or near-commercial.

Source: Extracted from Congressional Research Service issue brief #IB 77088 dated January 4, 1982.

CURRENT STATUS AND COST OF THE CRBR PROJECT

In 1972, the CRBR project was expected to be completed and to begin operating in 1980 at a cost of $700 million. In the early 1970s, however, a number of environmental, technical, and economic issues surfaced which necessitated a reappraisal of the cost and schedule estimates. As a result, by 1974 the scheduled plant operational date had slipped to 1982 and the cost estimate had risen to $1.7 billion. The demise of AEC and the creation of ERDA brought increased competition for research and development funds, and in a 1976 revised LMFBR program plan, ERDA further slipped the project's operating date to 1983 and revised the cost estimate to $1.9 billion. The CRBR project continued under ERDA's revised LMFBR program plan of April 1977.

From April 1977, until the present, the construction of the CRBR project has been delayed. The Carter Administration, which tried unsuccessfully to stop funding for the project, was able to get the Nuclear Regulatory Commission (NRC) to stop all licensing activities related to the project in 1977 before construction work started. 1/ Nevertheless, the Congress continued to fund the project. As a result, work on the final design of the CRBR project as well as its associated research and development is almost complete. Hardware manufacturing is continuing from its present level of about 60 percent delivered or ordered.

At the Reagan Administration's request, the NRC resumed its licensing activities in September 1981 and currently projects that consideration of a limited work authorization will be completed by mid-1983. If DOE does not start construction until 1983, DOE officials told us that the plant could be operational by 1990. The project would then begin its 5-year operation period. Because of the numerous delays over the past few years, DOE is completely reworking its construction schedule for the CRBR.

Since the project's inception, there has been continuing cost increases resulting from, among other things, added safety provisions, transfer of certain base technology programs to the project, schedule changes and general escalation. According to information we obtained from DOE, total estimated cost for the CRBR project is now about $3.2 billion. Included in this figure

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1/Before any work can begin at the site, DOE must obtain appropriate authorization from NRC.

is a net revenue of about $166.7 million 1/ that DOE expects to earn during the 5-year demonstration period from generating electricity to a power grid. The following table provides a cost breakdown of the project.

Estimated Cost of CRBR Project
(millions of expenditure year dollars)

Year	Total costs	Private sector contribution	Federal budget outlays
Thru fiscal year 1981	$1,148.2	$118.0	$1,030.2
1982	218.6	23.7	194.9
Thru completion	1,829.7	221.0	1,608.7
Total	$3,196.5	$362.7	$2,833.8

The figures in the table include an allowance for contingencies to cover uncertainties in the scope of the project, all engineering, construction and support activities, 5 years of demonstration, and an assumed 8 percent annual inflation rate. DOE is in the process of recosting the entire project. DOE officials told us that these figures should be available by the summer of 1982.

1/Total revenue generated less operating expenses.

Department of Energy
Washington, D.C. 20585

MAY 1 2 1982

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

Dear Mr. Peach:

The Department of Energy appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report entitled "The Liquid Metal Fast Breeder Reactor--Options for Deciding Future Pace and Direction."

We take strong exception to the fundamental premise underlying this report, that a commercial breeder will not be needed or economically competitive for 40 to 50 years, and as a result, we believe the report should not be issued without major revision! At this critical time of economic uncertainty and transition in energy use patterns, this report could precipitate a series of events that could ultimately threaten our national security through the unavailability of a critically needed, abundant, domestic energy resource.

The overall deficiency of the draft report cannot be overcome by simply correcting factual errors or addressing our comments in a separate section. The entire thrust of the report should be redirected. The fundamental error is that the report assumes that the key benchmark for development of a breeder strategy is the quantitative determination of the precise date for introduction of the Liquid Metal Fast Breeder Reactor (LMFBR). This introduction is based on estimates of the future number of light water reactors in operation and the presumed endowment of uranium. This approach to LMFBR decisionmaking was appropriate in the early 1970's when the anticipated tremendous growth in nuclear capacity indicated a near-term depletion of uranium. The question then was "When do we <u>have</u> to have the breeder?", and the answer was used to formulate a detailed program plan to meet that need.

Today, this simplistic approach is not appropriate. Today's environment is highly complex, driven by changing economic conditions, major shifts in energy use patterns, and the emergence of energy as a political issue in the United States as well as abroad. Recognizing this complex environment for decisionmaking, the breeder must be considered on its merits, <u>not</u> as a technology of "last resort." It should be evaluated as a renewable energy resource much like solar and fusion, with due consideration given to the broad range of technical, national security, economic, institutional, and political issues, including its state of development and potential contribution. The question that should be asked today is, "Is it in the national interest to continue development of the LMFBR at the present pace?"

The risk to the Nation of not having the breeder option available is much greater than the cost of the research and development program. This program is structured to develop the breeder to a point such that it can be introduced into the energy supply system at the time and to the extent deemed appropriate by the private sector.

We believe that a commercial breeder option must be available to this country to meet future National energy needs. It is true that changes have occurred in the Nation's energy supply-demand picture that suggest new technologies, like the breeder, can be gradually phased into the Nation's energy mix over longer periods of time than previously expected. However, the process of commercial acceptance can start early, as soon as the marketplace perceives advantages compared to other options.

The validity of the assumptions on which the report depends is based heavily on the recently experienced downturn in the growth of electric power demand and the current dormant status of new nuclear plant orders. Planning for the future on this basis would be a more grievous error than past planning based on the generally accepted estimates of high electric growth made before 1973, which were based on decades of historical trends. It is our view that a much better approach to an assessment would be to recognize the strong relationship between the economy and the availability of energy, particularly electric power, and focus on those actions necessary to restore healthy growth to the Nation's economy. High inflation, low economic growth, and high unemployment are with us today, at least partly as a result of the energy crises of the 1970's. The report accepts these current economic conditions as the framework for weighing options of critical importance to the Nation's economic future and growth. Future planning should not be based on a stagnant or shrinking economy, but rather on the realistic expectation of economic growth which experience shows will correlate closely with growth in electric demand.

Current U.S. electric generating capacity is about 640,000 megawatts. Since the oil embargo of 1973, demand for electric energy has followed the downward trend of the economy but has continued to grow at a slightly higher average rate (about 1.1 times) than the gross national product. Assuming a very modest 2 to 3 percent real growth in the Nation's economy, this generating capacity will double in the next 20 to 30 years. In addition, during that period, much of the current installed generating capacity will have to be replaced as it reaches the end of its useful service life. A significant fraction of today's capacity is made up of either very old and sometimes inoperable fossil units kept on the books for ratemaking purposes, or oil fired plants. It is unrealistic to assume that all of the needed new and replacement capacity will be met by coal and alternative undemonstrated renewables. Indeed, the same logic used in the report (cost, financing, public perception, environmental impact, potential, etc.) could be used to say that these alternatives will not be available to meet the demand.

In discussing the options, the report places decisive reliance on previous and recent projections, analyses, and studies involving estimates of electricity demand, uranium endowment and depletion, and price increases to offset presumed higher breeder costs. We have discussed the broader perspective described herein on several occasions with your staff as well as many detailed comments not addressed herein and pointed out the drawbacks of the historic approach.

It should be recognized that nuclear power, including the breeder, has considerable momentum worldwide. Other countries such as France and the USSR are currently proceeding with ambitious commercialization plans. In contrast, the GAO report appears to recommend continuing the U.S. breeder program on a stretched-out schedule of research and development.

Finally, the report as tendered does not deal with the implications to the Nation if the implied recommendation--namely, slowing the pace of the program--is ultimately proven incorrect. Industrial disruptions, constrained economic growth, and increased reliance on foreign supply can be expected if adequate economic supplies of energy are not available. This is a future clearly unconscionable to impose on future generations. Slowing the program will retard progress, diffuse and disperse the highly-trained manpower, and cause this Nation to settle for an international status that is second best and pose a very real threat of foreclosing the use of nuclear power in the United States.

Because nuclear power, and the breeder in particular, has become so highly politicized, the most likely outcome of the report as currently drafted is that it will be seized upon by the opponents of nuclear power to suggest termination of the program. A careful analysis of all factors bearing on the scope, pace, and timing of the LMFBR program will support its continuation and the expeditious completion of the Clinch River Breeder Reactor, a course of action which is now and has been clearly in the national interest.

Sincerely,

William S. Heffelfinger

William S. Heffelfinger
Assistant Secretary
Management and Administration

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