BY THE COMPTROLLER GENERAL

113359

Report To The Congress

OF THE UNITED STATES

U.S. Fast Breeder Reactor Program Needs Direction

The United States nuclear fast breeder reactor program

--is in a state of disarray,

--lacks direction, and

--costs hundreds of millions of dollars a year.

Because of the fast breeder development strategy now being followed, the United States may not be able to have a commercially available technology if and when it is needed.

The key to resolving these problems is a clear understanding and agreement between the Executive Branch and the Congress on the future role of nuclear energy in the United States' energy supply mix.

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

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

This report discusses the Department of Energy's nuclear breeder reactor program. It was done as part of our continuing reassessment of critical national issues.

The overall objective of the report is to provide congressional decisionmakers with a timely evaluation of the program in order to make some contribution to an informed and productive dialogue on the best way to proceed with this very expensive energy technology development program. In this regard, the report provides an analysis of what we believe are key issues surrounding the management of the program. Specifically, the report addresses the following questions.

--Is the administration's rationale for redirecting the U.S. breeder program sound?

--Is the U.S. liquid metal fast breeder reactor program being effectively managed?

--Is a backup to the liquid metal fast breeder reactor program needed?

We are sending copies of this report to the Secretary of Energy, and to the Director, Office of Management and Budget.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

U.S BREEDER REACTOR
PROGRAM NEEDS DIRECTION

D I G E S T

For more than 3 years the administration and the Congress have been unable to agree on the future role of fast nuclear breeder reactors in the United States. The issue boils down to whether the United States wishes to rely on nuclear power as a long- or short-term energy supply source.

If a long-term future for nuclear power is desired or even if the future role of nuclear power is viewed as uncertain but a nuclear option is to be maintained, constructing and operating a fast breeder demonstration plant is needed. On the other hand, if nuclear power is seen as having only a short-term role, the need to continue the breeder program is eliminated.

ADMINISTRATION'S STRATEGY IS RISKY

The liquid metal fast breeder reactor (LMFBR) program was accorded top priority until 1977 when the current administration significantly stretched out the program's proposed commercialization date from 1986 to about the year 2020. The new policy was founded on

--concern that plutonium-based nuclear fuels may lead to international nuclear weapons proliferation;

--projections supporting a diminished need for commercial breeder reactors because of reduced electrical energy growth forecasts and more plentiful uranium resources to fuel conventional light water reactors;

--projections that LMFBRs would not become economically competitive for several decades;

--questions about the safety of LMFBRs; and

--the belief that the Clinch River Breeder Reactor was too small, too costly, and technically obsolete.

GAO believes this policy is based on uncertain data and not supported by the evidence.

--The current strategy will not necessarily enable this country to achieve its non-proliferation goals. (See p. 10.)

--The projections of the availability of uranium are uncertain. (See p. 13.)

--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. (See p. 18.)

--The ultimate economics of the LMFBR are difficult to accurately project. (See p. 21.)

--The LMFBR is no more or less safe than the current generation of light water reactors. (See p. 22.)

PROGRAM HAS NO DIRECTION

Regardless of the validity of the administration's contention that commercial LMFBRs will not be needed before the year 2020, the United States may not even be able to meet this date. The LMFBR program:

--Lacks a clear mission and focus resulting in a considerable waste of time and money. (See p. 23.)

--Does not include assurance that the requisite institutional conditions for commercializing the option--industrial capability and utility confidence--will be in place to allow for a smooth transition to this energy supply option if and when it is needed. (See p. 29.)

The disagreement that has characterized the fast breeder program, specifically the LMFBR, for the past 3 years has made planning and directing the program difficult for DOE.

Currently, the administration is not supporting any overall program plan that details an LMFBR development strategy although many have been proposed by DOE. After three decades and several billion dollars of research and development on this energy system, DOE officials were unable to provide GAO with an approved and generally accepted plan on how to secure the LMFBR option by the year 2020 even though they recognize the need to have such a plan.

The more immediate problem facing DOE, however, is the lack of a specific plant commitment that would serve to focus the LMFBR base technology research and development work being done at its laboratory and contractor facilities toward some definable and measurable end use. With the uncertainty surrounding the Clinch River plant and the lack of an administration commitment to any demonstration plant, the LMFBR program has become unstructured and program progress is becoming increasingly difficult to define and measure.

The Congress has continued funding the Clinch River plant every year since 1977, despite the administration's repeated attempts to kill the project. Even with continued funding, however, no work has begun on constructing the facility. Recent actions by the administration underscore its desire to kill the Clinch River project and to defer any commitment for a substitute plant. Specifically

--the fiscal year 1981 budget submitted to the Congress again calls for termination of the Clinch River plant;

--the Nuclear Regulatory Commission licensing staff that is necessary for the Clinch River project to move toward construction has been dispersed;

--the fiscal year 1981 budget is requesting that the Nuclear Regulatory Commission's LMFBR safety research program be terminated; a move that, according to the Commission, could cost the LMFBR program about 10 years of development time if work is ever resumed; and

--a decision on whether to construct a substitute plant for the Clinch River facility, scheduled for March 1981, has not been supported in the administration's fiscal year 1981 budget request.

Thus, it is probable, that another year of indecision is facing the LMFBR program.

TERMINATION OF GAS-COOLED FAST BREEDER REACTOR PROGRAM IS PREMATURE

The gas-cooled fast breeder reactor and the light water breeder reactor programs are being carried out as backups to the LMFBR program. However, in fiscal year 1981 DOE is planning to terminate its participation in the gas-cooled fast breeder reactor program while continuing to fund the light water breeder reactor program. But, according to DOE officials, the light water breeder reactor program cannot be viewed as an alternative or backup to LMFBRs because its objective and purpose are different. Accordingly, the United States will be left with no real nuclear alternative to the LMFBR technology if unforeseen or unanticipated technical or institutional obstacles prevent it from becoming the Nation's primary nuclear energy supply system. DOE's withdrawal from participation in the technology development program will probably cause the collapse of the industrial infrastructure that has grown in support of the program and, consequently, the only nuclear alternative to the LMFBR program will be lost. (See p. 36.)

CONCLUSIONS

Over the past several years both the Congress and the administration have endorsed the need for maintaining a strong LMFBR program in this country. However, a strong LMFBR program includes constructing and operating a plant--

something which has not been done. Consequently, if this country wants to rely on nuclear power as a long-term energy source or even if it chooses only to preserve a future energy supply option for possible use if other energy technologies cannot carry the load, the information gathered by GAO supports the position that fast breeder technology should move forward to the construction and operation of a LMFBR demonstration plant. In fact, the Congress, by continuing its support over the last 3 years for constructing and operating a demonstration plant, appears to have chosen this path. In this regard, however, it should be noted that constructing and operating a LMFBR plant that would serve to demonstrate the viability of the technology should not be viewed as an irrevocable commitment to commercially deploy the technology. These can be and should be two distinct phases of the overall development process.

In contrast, however, the administration, by its rigid opposition to constructing any breeder plants, has chosen a different path. So, if the program is to move forward, GAO believes it is necessary that the circle of debate between Congress and the administration be broken and that a clear and firm commitment on the long-term role of nuclear power be made. Recognizing the administration's position on this matter, the only real alternative is for the Congress to shoulder this burden.

In addition, to the extent the Congress wants to rely on nuclear power as a long-term energy supply source or wants to maintain a long-term nuclear option, prudent management dictates that a backup technology be available for timely development in case the LMFBR program does not meet its objectives. The gas-cooled breeder program can provide this needed backup capability. Consequently, the program should continue at least until it reaches a decision point on whether to construct and operate a demonstration facility--now scheduled for about 1984.

RECOMMENDATIONS TO THE CONGRESS

If Congress wishes to maintain a nuclear option or if it wishes to commit to nuclear power as a long-term energy source, GAO recommends that it require DOE to demonstrate the viability of the LMFBR technology by mandating the construction of a breeder reactor facility. However, in making this recommendation, GAO wants to emphasize that it is not necessarily advocating the completion of the Clinch River project as the only means of moving the program forward. The only resolution to the impasse may be to move ahead with a larger, more recently designed facility instead of the Clincher Project.

In GAO's opinion, the imposition of a plant commitment on DOE would help foster a more appropriate U.S. breeder reactor research, development and demonstration posture. As part of this mandate, however, 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.

Further, a commitment to a long-term nuclear option should include continued support for the gas-cooled fast breeder reactor program since it is currently the only real nuclear alternative to the LMFBR technology. Accordingly, GAO recommends that Congress continue to fund the program at least until the program reaches a decision point on whether to construct and operate a demonstration facility. Such an approach is essential as a prudent management step in helping assure the timely success of this Nation's nuclear energy future.

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

To continue to fund the program at several hundred million dollars a year to keep the scientific and engineering teams together is hard to justify. GAO points out, however, that if the program is terminated it could cost many years of developmental time if the Congress later chooses to restart it. If this should occur, the only available alternative may be to purchase breeder reactors from some more advanced, foreign nation.

AGENCY COMMENTS

The Department of Energy provided written comments on this report. Essentially, they agree that for effective management and resource utilization, a central organizing principle and a schedule are desirable for the program. Moreover, the Department recognizes that there is now no national policy guidance on whether or when breeder reactors will need to be deployed. On the other hand, the Department states that it has developed a rational approach for the development of the technology, should a national policy dictate the need to do so. A summary of the Department's comments and GAO's evaluation of them is included in chapter 5 of the report. The complete text of the Department's comments is included as appendix I.

Contents

ABBREVIATIONS

CRBR Clinch River Breeder Reactor
DOE Department of Energy
GAO General Accounting Office
GCFR Gas-Cooled Fast Breeder Reactor
INFCE International Nuclear Fuel Cycle Evaluation
LMFBR Liquid Metal Fast Breeder Reactor
LWBR Light Water Breeder Reactor
LWR Light Water Reactor
NASAP Nonproliferation Alternative Systems Assessment Program
NRC Nuclear Regulatory Commission

CHAPTER 1

INTRODUCTION

BACKGROUND

Before 1973, there were few restraints on energy consumption in the industrial nations of the world. Traditional fuels--natural gas, oil, coal, and hydroelectric power provided cheap energy, and a new electrical energy source--uranium--was rapidly being used to replace oil and gas in the long term. However, the 1973-74 oil embargo and subsequent events made the major industralized countries of the world painfully aware of the vulnerability of relying on imported oil for so much of their domestic energy. Recognizing that industrialized nations, particularly the United States, were relying more on imported oil while the world's known oil reserves were rapidly declining intensified the oil embargo's short-term effects. In addition, concern increased over the adverse environmental impacts of mining and burning coal, one of our most abundant energy resources. As a result, domestic utilities and foreign countries increasingly turned to nuclear power in the early 1970s.

Today, 70 commercially-owned nuclear powerplants generate about 10 percent of this country's electricity. Another 99 plants are under construction or planned. All but one of these plants are conventional water-cooled reactors, usually referred to as light water reactors (LWRs), which make relatively inefficient use--1 or 2 percent--of the energy potential in uranium fuel.

From the nuclear power program's beginning, the Federal Government and the nuclear industry recognized that uranium resources are limited and long-term plans for nuclear power required more efficient uranium resource use. A breeder reactor, which produces more useable nuclear fuel than it consumes, would accomplish this objective. If reprocessed, the nuclear fuel produced in breeder reactors could be used to fuel other breeder reactors as well as LWRs.

With breeder reactors, nuclear energy was seen as a major electrical energy source for several centuries. This could be done using only the known uranium reserves plus the 280,000 tons of depleted uranium (natural uranium from which most of the useable uranium fuel has been removed) now stockpiled as "waste" at the nation's uranium enrichment plants. Some estimates place the billion barrels of oil--approximately the estimated oil resources of the entire world. The equivalent dollar value at $29 a barrel is nearly $70 trillion or about $320,000 for every resident of the United States. The depleted uranium stockpiles could theoretically provide a means of meeting our total electrical energy needs for several centuries without any additional mining of uranium. The energy potential of the nation's unmined, high-probability uranium reserves if used in breeders has been calculated to be larger than the estimated energy contained in the entire world's supply of coal, oil, and gas and is worth $380 trillion based on oil's equivalent value at $29 a barrel.

THE ORIGIN AND EVOLUTION OF THE U.S. BREEDER REACTOR PROGRAM

From the mid-1940s, various research projects have been undertaken in breeder reactor technology and, in 1951, the first nuclear electricity ever produced was made in an experimental breeder reactor. Despite this early interest, however, the less resource-efficient light water reactor technology progressed more rapidly and was brought into early commercial use. That happened, in part, because of its early use in naval propulsion systems and because the U.S. industry regarded it as a smaller departure from the familiar technology of fossil fuel electric plants.

After commercializing the LWR, the Federal reactor program focus shifted toward breeder reactor technology in the mid-1960s. Several types of breeder reactors were being developed: (1) the molten salt breeder, (2) the light-water breeder, (3) the gas-cooled fast breeder, and (4) the liquid metal fast breeder (LMFBR). In 1967, after evaluating ongoing reactor programs and research results, the Atomic Energy Commission 1/ declared the LMFBR to be its highest reactor development priority. The Commission decided to marshal available resources and apply them to a single priority because it believed continued diffuse attention to a spectrum of interesting reactor types would not assure success. The LMFBR was given priority over other breeder concepts because of its (1) predicted performance, (2) more efficient use of the energy potential in uranium (3) existing industrial support, (4) technological

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1/The Atomic Energy Commission and Energy Research and Development Administration were both predecessors of what is now the Department of Energy.

experience, and (5) its proven feasibility--six small LMFBRs had been constructed in this country between 1946 and 1963.

The Atomic Energy Commission continued to fund research for the other three breeder reactor concepts, however, but at a less aggressive pace. These other concepts were continued as backups to the LMFBR and were not considered serious contributors to the nuclear energy program. The Commission's emphasis on the LMFBR, and subsequent deemphasis and decreased funding of other breeder concepts, provoked considerable controversy. Opponents criticized the Government for "placing all its eggs in one basket." They believed alternative breeder types should be equally researched and funded as insurance against the possibility that LMFBRs would run into difficulties preventing its widespread adoption.

Recent U.S. progress

Since the LMFBR concept was selected and accorded the highest priority in the civilian reactor development program, one small LMFBR--the Fast Flux Test Facility--has been built for testing fuels, materials, and components. This facility is a test reactor that has no capability to generate electricity, nor is it intended to demonstrate the breeding of fuel. However, since the late 1960s the United States has been planning one or more LMFBR demonstration plants, the first being a 375 megawatt 1/ plant, the Clinch River Breeder Reactor (CRBR) Plant project.

In 1971 the President reemphasized the high priority being given to the breeder program, expressed support for a second demonstration project, and established a 1980 goal for completing the CRBR. The LMFBR became the Federal Government's most heavily funded nuclear concept. However, in 1971-74, many public and private organizations challenged this approach. As a result, in 1972 a Federal court directed the Atomic Energy Commission to prepare a comprehensive Environmental Impact Statement on the entire LMFBR program. After several years of effort, the Environmental Impact Statement was concluded.

Based on its findings, the Energy Research and Development Administration--successor of the Atomic Energy Commission--revised its breeder program in 1976. The revised program again emphasized plant experience, to be gained through a sequence of powerplant and fuel reprocessing demonstration projects. The specific plant projects were to serve as a vehicle for the transfer of the technology from research

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1/A megawatt is equal to 1 million watts.

and development to commercial use. In addition, the program involved extensive utility and industry participation. Specifically, the 1976 LMFBR plan required that

--a decision on whether to commercialize LMFBR technology be made by 1986;

--all outstanding environmental, technical, and economic issues be resolved by 1986; and

--the program be in a state of readiness should a decision be made in 1986 to deploy the breeder.

Under this program the demonstration projects were supported by a broad-base technology program which would develop needed engineering and scientific information in major technology areas such as safety, component technology, physics, materials and chemistry, and fuels. These activities were to be carried out by the Energy Research and Development Administration's national laboratories and engineering centers and by many industrial contractors. And, while the objectives of the program did not explicitly include commercialization of the LMFBR, they did include assurances of requisite institutional conditions for commercialization--industrial capability and utility confidence.

Foreign programs

Almost concurrently with the United States, other major industrial nations also pursued the LMFBR technology. They, like the United States, foresaw the need for an energy source to supplement traditional fuels and have committed substantial resources to this energy option. For example, the Soviet Union has operated a 350-megawatt electric plant since 1972 and a 600-megawatt electric plant began operating this year. France and the United Kingdom have been operating 250-megawatt electric plants since mid-1974. In addition, France is constructing a 1,200-megawatt plant and has plans for several follow-on reactors. And, several other countries, including the Soviet Union and West Germany, are designing larger plants.

NUCLEAR POLICY REDIRECTION IN 1977

On April 7, 1977, the current administration proposed a major redirection in U.S. nuclear energy policies and for the most part it was aimed at the breeder reactor program. Specifically, the administration proposed (1) deferring indefinitely commercial reprocessing and LMFBR commercialization, (2) redirecting the LMFBR program to evaluate alternative breeders, advanced converter reactors, and other alternative nuclear fuel cycles, and (3) canceling the CRBR. The administration's new policy was founded on

--concern that plutonium-based nuclear fuels would lead to nuclear weapons proliferation;

--projections supporting diminished need for commercial breeder reactors because of reduced electrical energy growth forecasts and larger estimated uranium resources to fuel conventional LWRs; and

--the belief that CRBR was too small, too costly, and technically obsolete.

Also, since its April 1977 announcement the administration has begun questioning the economics and generic safety of LMFBRs. This concern was amplified following the Three Mile Island accident in a LWR plant near Harrisburg, Pennsylvania.

As a result of the administration's revised nuclear policy proposals, DOE reevaluated the direction of its nuclear programs. The LMFBR program objective was modified from that of building demonstration projects to conducting broader research and development activities. This included curtailing work on CRBR except for completing system designs and testing key components, and redirecting the LMFBR base research program to emphasize alternative fuels and fuel cycles which might be more proliferation resistant. In contrast to the pre-1977 program, the revised program did not include a commitment to a demonstration reactor plant or any other operating breeder reactor.

The Congress, however, has been unwilling for the most part to go along with this new approach and has consistently refused to discontinue CRBR believing this would be tantamount to killing the program. For the past 3 years, Congress and the administration have been at a stalemate on how best to proceed.

Accordingly, while the CRBR issue is being debated, DOE is conducting a conceptual design study of a plant larger than CRBR. This study, a totally Government-funded and managed effort, is to develop an integrated plant design based on plant safety, environmental acceptability, proliferation resistance, economics, and reliability. This approach is now the driving force of the breeder program. In the meantime, the CRBR is "marching in place." Critics contend that the revised program lacks focus and needs a commitment to construct, operate, and demonstrate the technical and economic feasibility of a larger breeder reactor plant that would make breeder technology an attractive electrical energy option to the utility industry.

In addition to the conceptual design study, two nonproliferation assessment studies have been conducted as a result of the administration's nonproliferation strategy--the International Nuclear Fuel Cycle Evaluation (INFCE) study and the Nonproliferation Alternative Systems Assessment Program (NASAP) study. The administration's nuclear policy proposals established the U.S.-sponsored INFCE program--involving 53 countries and 4 international organizations--to identify proliferation control alternatives for nations with common nonproliferation objectives. The U.S. role was supported by DOE's domestic study--NASAP. Although begun in late 1976, NASAP was restructured to respond to President Carter's April 1977 policy statement. NASAP's overall goal was to recommend civilian nuclear power systems which, when deployed internationally, would offer improved proliferation resistance as compared to systems that permit access to plutonium, highly enriched uranium, or other materials directly useable in nuclear weapons as LMFBRs would. The results of these studies, along with the conceptual design study, were designed to further define the future role of breeder reactors and their development strategy.

Although studies and debates continue on the future role of breeder reactors, the administration continues to support, and the Congress continues to fund, a large research and development program for the LMFBR concept. Congress has appropriated $564 million, $566 million, and $618 million, for fiscal years 1978, 1979, and 1980, respectively, for the program. The proposed budget for fiscal year 1981, however, recommends significant changes to the breeder program. The Office of Management and Budget reduced DOE's LMFBR program request of $520 million to $320 million. In addition, the administration's latest budget proposal does not support a decision to build and operate the next demonstration plant.

Further, the proposed fiscal year 1981 budget eliminates gas-cooled breeder reactor funding. The gas-cooled breeder reactor was funded as a LMFBR backup, but because of recent decisions to stretch out the LMFBR program and defer commitments to construct breeder reactor plants, it is no longer considered necessary by the administration. The light water breeder reactor is the only breeder option to maintain its fiscal year 1980 funding level in the fiscal year 1981 proposed budget.

OBJECTIVES, SCOPE, AND METHODOLOGY

During the past 6 years, we have reported on many aspects of the LMFBR program, as well as other breeder reactor programs. More recently, a May 1979 report 1/ discussed the administration's reasons for wanting to terminate the CRBR project, but concluded that the project should continue to be funded if the United States wanted to maintain a strong LMFBR program. A later report, issued in July 1979, reemphasized this position. 2/

For 3 years now, the Congress and the administration have debated the need for LMFBRs and whether the CRBR plant should be constructed. At the same time, a great deal of uncertainty has existed over the future role of nuclear power in this nation's energy future. Consequently, because the program is the single most expensive nuclear research and development program within DOE; because of the uncertainty created by this continued debate; and because of the complete turnaround in the program's objectives, we reviewed the overall program to determine what effect these conditions have had, if any, on the U.S. LMFBR program, specifically, and on the entire breeder reactor program, in general. In addition, we also reviewed the administration's rationale for redirecting the program since it is the source of most of the programmatic changes that have occurred over the past 3 years.

Our overall objective was to provide congressional decisionmakers with an up-to-date evaluation of the program and to contribute to an informed and productive dialogue on the best way to proceed with this very important and very expensive energy technology development program. To achieve this objective, we attempted to answer the following questions:

1. Is the administration's rationale for redirecting the U.S. breeder program sound?

2. Is the U.S. LMFBR program being effectively managed?

1/"The Clinch River Breeder Reactor--Should Congress Continue to Fund It?" U.S. General Accounting Office, EMD-79-62, May 7, 1979.

2/"Comments on the Administration's White Paper Entitled 'Clinch River Breeder Reactor--An End to the Impasse,'" U.S. General Accounting Office, EMD-79-89, July 10, 1979.

3. Is a backup to the LMFBR program needed?

The following chapters discuss our answers to each of these questions in detail.

In attempting to answer these questions, we interviewed responsible officials from DOE, NRC, industry, utilities, national laboratories, academia, trade associations, and environmental groups, as well as several knowledgeable private citizens. We supplemented the interviews by collecting, examining, and analyzing a broad array of DOE and NRC internal reports, studies and other pertinent correspondence on the issues surrounding the scope, structure, and pace of the LMFBR and other breeder programs. In addition, we reviewed a wide range of studies and professional papers that have been done over the last several years on various aspects of the United States nuclear and nonnuclear energy program. Particularly, we relied heavily on the information contained in three major studies that were completed while our review was underway --INFCE, NASAP, and a National Academy of Science's study entitled, "Energy in Transition--1985 to 2010." We also obtained information through correspondence with 19 utility companies, 2 nuclear reactor manufacturers, and an architect engineering company. The correspondence was further supported by telephone discussions with several of the utility and industry respondents. A list of these organizations is included as appendix II.

In addition to these sources, we relied heavily on our previous reviews of the breeder reactor program. Since 1974 we have issued 14 reports on various aspects of this country's nuclear breeder reactor program. Specifically, we have reviewed the LMFBR program from its early stages through the administration's redirection of the program in 1977. Likewise, we have followed the progress of the CRBR project from its planning stage through its proposed termination by the administration. Through these reviews, we have acquired a base knowledge and understanding of the goals and objectives of the program as they have evolved. This has given us a unique insight into the current status of the breeder reactor program.

A draft version of this report was reviewed by DOE officials. Where appropriate, changes based on DOE's review were made to the report.

CHAPTER 2

THE REDIRECTED BREEDER STRATEGY

IS RISKY

The administration's strategy for breeder reactor development is predicated on a commercial breeder deployment schedule beginning about 2020. The so-called "need" date has become the driving force behind the overall planning of DOE's breeder reactor program. This date is considerably later than was provided for in DOE's technology development plans prior to 1977. Critics of the revised program contend that it is too little and too late. Its supporters, on the other hand, counter that the program more realistically reflects when commercial breeder reactors may be needed in this country.

The administration has cited the following reasons for its decision to stretch out the breeder program

--concern that worldwide reliance on breeder reactors would lead to the proliferation of nuclear weapons,

--projections that commercial breeder reactors were not needed as soon as previously thought because of reduced electrical energy growth forecasts and because of larger estimated uranium resources to fuel conventional light water reactors,

--projections that LMFBRs would not become economically competitive for several decades,

--concern that LMFBR technology presented greater safety challenges than light water reactors, and

--the CRBRs technical obsolescence, small size, and large costs.

Except for the last one, we analyzed each of these issues. We did not analyze the last issue because it has already been the subject of a report we issued in May 1979. The report concluded that the CRBR was not technologically obsolete, too small or too expensive. 1/

1/"The Clinch River Breeder Reactor--Should the Congress Continue to Fund It?" EMD-79-62, May 7, 1979.

Generally, our analysis showed that the reasons cited by the administration for delaying breeder development are founded on uncertain data and are not supported by the majority of those we interviewed. Specifically, we found that

--the current strategy will not necessarily enable this country to achieve its nonproliferation goals,

--the projections of the availability of uranium are uncertain,

--unanticipated events, such as the cut-off of Persian Gulf oil, could increase the demand for nuclear energy and thus the need of an early commercialization of the LMFBR,

--the economics of the LMFBR are difficult to accurately project, and

--the LMFBR is no more or less safe than current light water reactors.

As a result of the uncertainty associated with many of the administration's assumptions about the breeder program, the path of breeder development called for by the current strategy could result in the United States being unable to timely respond to its energy supply needs. Further, the pace of breeder reactor development now being pursued takes the less conservative route of building the risks of breeder development into the later stages of the program where errors in judgment or miscalculations in planning estimates can be least tolerated, instead of into the early stages of the program where the margin for error is greater.

CURRENT STRATEGY NOT ACHIEVING U.S. NONPROLIFERATION GOALS

While the administration recognizes the need for nuclear power to supply domestic energy needs, it also recognizes serious nuclear proliferation dangers inherent in handling, processing, and transporting nuclear fuels. Moreover, the administration contends that these dangers will be unnecessarily increased by the premature introduction of nuclear technologies that involve the recycling of weapons-useable nuclear materials, as do all breeder reactors. In an effort to discourage the further spread of nuclear weapons to other nations or subnational groups, the U.S. policy is to delay the development of the breeder and its supporting reprocessing technologies.

However, recent studies as well as continued pursuit of breeder technology by other countries raise questions about the credibility of the approach being taken by the United States. Since 1977 several studies have been done by various groups and organizations, including us, on the effects of breeder reactor development on U.S. non-proliferation goals. At least five of these studies--those done by the Congressional Research Service, 1/ the NASAP study group, the INFCE study group, the Office of Technology Assessment, 2/ and us 3/--concluded that no single path among known nuclear fuel cycles involving reprocessing is substantially less proliferation prone than another. Moreover, a highly influential report by the Ford Foundation issued in 1977 4/ concluded that research or small production reactors would be a much more suitable and likely means for producing weapons-useable material than would reprocessing plants associated with a commercial power reactor fuel cycle. The Ford Foundation study noted that research or small production reactors would cost substantially less and take less time to construct; involve relatively simple rather than complex reprocessing technology; can yield a comparable number of explosive devices per year; and have much lower detectability of clandestine facilities. Indeed, it is a historical fact that all plutonium used for weapons to date has been produced in research reactors or special military production reactors; not from commercial powerplants. Furthermore, DOE officials told us that the information available to them suggests that this practice will probably continue.

1/"Alternative Breeding Cycles for Nuclear Power: An Analysis," Congressional Research Service, Library of Congress, Oct. 1978.

2/"Nuclear Proliferation and Safeguards," Office of Technology Assessment, June 30, 1977.

3/"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.

4/"Nuclear Power Issues and Choices," Ford Foundation, Mar. 1977.

Both the NASAP and INFCE studies concluded that no technical solution exists to the proliferation dilemma because all nuclear fuel cycles entail some proliferation risks. In addition, the reports pointed out that, with the exception of the conventional light water reactor without fuel reprocessing, other fuel cycles do not offer inherent proliferation advantages over the LMFBR. The INFCE study group went further than this by concluding that the nuclear material diversion risks encountered in the breeder reactor fuel cycle present no greater difficulties than the light water reactor with reprocessing or even the once-through or throwaway cycle over the long term. Further, the NASAP and INFCE groups concluded that institutional controls and multinational safeguards efforts are the best means for reducing worldwide nuclear proliferation risks.

While the administration had hoped its actions on the LMFBR program and CRBR would influence other nations to delay breeder reactors until more proliferation resistant breeder technologies and more institutional arrangements could be developed, it does not appear to be working. Despite the urgings of the U.S. Government, breeder programs are proceeding in other nations. Great Britain, France, and the Soviet Union are now operating LMFBR industrial-size plants and more are planned. Also, there are experimental breeder reactors operating in Germany and Japan. To be sure, substantial public dissent against breeder technology exists in these countries, but their governments appear convinced that expeditious development of the breeder reactor is necessary to meet their future energy needs.

Our earlier report 1/ cited conversations with European nuclear program officials who believe that rather than discouraging others from entering the nuclear arena, the U.S. nonproliferation posture may have given other nations additional incentives to accelerate development of indigenous nuclear industries and to launch vigorous research and development programs and export promotions. This view has been validated in a February 1980 report 2/ prepared by the minority staff of the House Committee on

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1/"The United States and International Energy Issues," U.S. General Accounting Office, EMD-78-105, Dec. 1978.

2/Report by the Minority Staff of the House Committee on Interior and Insular Affairs on a Trip to Several European Countries, Feb. 1980.

Interior and Insular Affairs based on recent discussions with the energy officials in several European countries.

According to this report, the European view of the U.S. nuclear energy policy is that our failure to develop a breeder will put great pressure on the world uranium supply. Consequently, some of these countries are pursuing breeder development more vigorously than before because of the additional uncertainty in uranium availability. In addition, foreign officials have pointed out that U.S. withdrawal from a mission-oriented LMFBR program will leave the United States with little influence on international safeguards and controls over the sale and use of breeder reactors. The history of the U.S. involvement in the worldwide light water reactor industry seems to demonstrate the soundness of this premise. According to NRC officials, the heavy U.S. activity in light water reactor development over the past two decades enabled this country to lead the way in establishing more stringent safety and licensing practices for conventional nuclear reactors than might otherwise have resulted. These practices have since been adopted by many countries throughout the world.

URANIUM AVAILABILITY PROJECTIONS ARE UNCERTAIN

The amount of uranium that is available to fuel conventional nuclear reactors is a key to if and when breeder reactors will be needed. Unfortunately, estimates of the amount of recoverable uranium that can be mined in this country are highly uncertain and consequently a wide divergence of opinion exists on the amount of future supplies. Some experts predict there will be adequate supplies well into the 21st century while other experts warn of shortages at about the turn of the century. Accordingly, an estimate exists to justify just about any date that might be chosen. DOE is now trying to improve U.S. uranium resource estimates through its National Uranium Resources Evaluation program. The program is scheduled for completion in 1987, with interim reports on revised estimates of U.S. resources scheduled for 1980 and 1983.

In the meantime, however, the administration has chosen to delay possible commercialization of the breeder based on its belief that domestic uranium supplies, coupled with several technology improvements it believes can extend the uranium resource base, will be sufficient to fuel the anticipated light water reactor program until that time. In view of the highly speculative nature of these estimates and the uncertainty involved in realizing these technology improvements, the administration's position is a gamble.

Uranium availability projections

Demand for uranium ore may be affected by such hard-to-quantify variables as future nuclear reactor growth, advances in reactor fuel efficiency and uranium enrichment technologies, availability of alternative energy sources, and public opposition as a result of incidents like the Three Mile Island accident. Likewise, the assurance of supply is subject to many variables such as the adequacy of uranium resources, production capability, and profitability. Further, other potential problems exist such as restricted access to Indian and Federal lands having uranium resouces, environmental and safety problems at uranium mines, and increased Federal and State licensing requirements and regulations. This is not to mention the drain on domestic uranium supply that could result if exports of uranium fuel are increased in pursuit of U.S. nonproliferation goals.

In addition to the uncertainties inherent in making demand and supply projections, further confusion results from DOE's classifications of uranium resources. DOE uses two categories of classification for uranium ore--reserves and potential resouces. Potential resources are further divided into probable, possible, and speculative classes. Reserves are the firmest element of resources, comprising deposits that have already been found in the United States. Probable, possible, and speculative resources are estimates, in declining order of reliability, of the uranium believed to be present in deposits that are incompletely defined or undiscovered.

While general agreement exists on the amount of reserves and probable resources, there are strong differences of opinion on the amount of possible and speculative resources that will be found and, accordingly, to what extent these categories should be used in planning the scope and pace of the U.S. nuclear energy development program. The Ford Foundation report and the Breeder Reactor Group Report, an unpublished report provided as input to the National Academy of Science's Committee on Nuclear and Alternative Energy Systems, illustrate how different interpretations of DOE resource classifications can result in conflicting conclusions on the availability of uranium. Both groups used DOE's 1977 uranium resource estimate of 3.6 million tons at

$30 forward cost 1/ as a base. This included 0.6 million tons of proven reserves, 1.1 million tons of probable resources, possible discoveries totaling 1.3 million tons, and speculative discoveries totaling 0.6 million tons. The Ford-Foundation report concluded that all DOE estimated reserves and resources, including possible and speculative, could be relied upon and, in fact, the report concluded that DOE's estimates were too low. On the other hand, the Breeder Reactor Group Report reported that as a basis for prudent planning, a figure of 1.8 million tons of uranium ore should be used. The Breeder Group also stated that there is a 97 percent probability that U.S. uranium resources are less than DOE's 1977 estimate.

We did not attempt to determine which, if either, of these uranium ore projections was correct. However, we did find that many knowledgeable sources agree that because of the speculative nature of the latter resource categories, these categories should be used cautiously in energy resource projections. In this regard, the Director of DOE's Division of Uranium Resources and Enrichment wrote

> "* * * ore reserves plus probable potential resources are generally accepted as a reliable basis for uranium supply projection. There is no general agreement on the extent to which we can rely on the possible and speculative categories. While these estimates are the best we know how to make, we have not yet developed methods to measure the confidence that can be placed in them, particularly so far as important national energy commitments are concerned."

The NASAP and INFCE studies also analyzed uranium availability. These studies, however, differed from the Ford-Foundation and National Academy of Science Studies in that they concentrated on uranium supply capabilities and not on uranium resources. While resources are only estimates of uranium that could be found; supply is the amount of uranium that can be produced and available in a given period of time. These studies reasoned that in using uranium resource data, constraints on capacity to supply the resources must be factored into the analysis. These supply constraints could include shortages of mining labor,

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1/Forward cost is the estimate of capital and operating costs not yet incurred that will be required to produce a pound of processed uranium at the time that estimate is made.

restricted access to public lands, lengthening licensing timetables and long construction leadtimes for uranium mining facilities. However, the studies did not include an analysis of the impact increased exports of uranium would have on U.S. uranium supplies. Many of those we interviewed thought increased exports of uranium are a very real possibility in view of existing U.S. nonproliferation objectives.

As with many other reports on this subject, it was not possible for either the NASAP or INFCE report to definitively conclude when imbalances in domestic uranium demand and supply would occur. Both reports concluded that it could happen as early as 2005 or as late as 2050. These analyses again illustrate the broad band of uncertainity that surrounds DOE's planning process.

Extending uranium resources

In addition to predictions about the uranium resource base, DOE's analyses on the need for and timing of breeder reactors relies on several technological improvements that could extend uranium resources. These improvements include (1) increased efficiency of light water reactors by 30 percent (2) introduction of advanced converter reactors, 1/ and (3) improved uranium enrichment techniques. In a planning document entitled "The Nuclear Strategy of the Department of Energy," DOE justified delaying the breeder development schedule based on these improvements. However, our analysis shows that achievement of these improvements in accordance with DOE's time schedule is uncertain and relying on them compounds an already unreliable uranium availability planning base.

DOE is doing research that its planners believe could increase the fuel efficiency of light water reactors 15 percent by 1988 and another 15 percent by the year 2000. They believe these improvements can extend uranium fuel resources about 5 to 8 years. Some of these improvements could be applied to operating plants or to plants now being designed or constructed--retrofittable--while other improvements would involve system and component changes and could only be installed in new plants--nonretrofittable.

1/An advanced converter reactor is a plant that provides better uranium fuel utilization than that obtained in present commercial light water reactors, but not as good as a breeder.

We discussed these improvements with officials at DOE's national laboratories and headquarters. We found a general consensus that technical improvements to light water reactor fuel efficiency can be achieved but that widespread implementation of these improvements is not guaranteed. The consensus was that retrofittable improvements could increase uranium utilization efficiency in individual reactors 10 percent by 1990 and by an additional 5 to 10 percent by 2000. Additional improvements are considered more speculative at this time because less work has been done toward their development and they involve changes in reactor plant systems and components. A DOE official responsible for the program told us, however, that while fuel improvements of 15 percent have been demonstrated and could be technically attainable by 1988, the program is at the mercy of the nuclear utility industry. He said that it is optimistic to assume at this time that the utilities will convert their reactors because initially only a small gain in fuel utilization can be realized, economically there is little incentive, and several technical problems have yet to be resolved. All officials generally concluded that, although some of these improvements are known to be technically achievable, they should not be relied upon at this time as a way to extend the uranium resource base and subsequently, delaying the breeder, because of uncertain acceptance by the utility industry.

Another concept being considered by DOE is the advanced converter reactor. DOE believes that advanced converters could reduce lifetime uranium requirements for a reactor by 40 percent and could be introduced in the year 2000. The advanced converters now available are the High Temperature Gas-Cooled Reactor and the Heavy Water Reactor. However, we found that while some fuel savings could be expected from advanced converter reactors, they are generally not considered to be at a stage of development where their commercial deployment is assured.

The fiscal year 1981 budget request eliminates funding for the High Temperature Gas-Cooled Reactor, and research and development for the Heavy Water Reactor is not currently being funded in the United States. Moreover, the consensus among those we interviewed is that the long leadtimes needed to develop and demonstrate these systems precludes their being brought into commercial use until after the year 2000. In addition, we found that their ability to significantly extend uranium resources remains to be proven and, consequently, must be viewed as uncertain. The NASAP report concluded that as a group, advanced reactors seem to offer only modest benefits in resource use. In addition, the NASAP report states that none of these systems would offer significant economic and proliferation advantages over light water reactors. For these reasons, it seems questionable that natural market forces alone could be expected to commercialize advanced converter reactor systems.

The third method of extending the uranium resource base is the development of new uranium enrichment techniques--advanced isotope separation--that would provide more nuclear fuel from a given amount of uranium resources. The effect of this would be the reduction of uranium ore requirements for light water reactors. These new enrichment techniques are currently under development and DOE planners believe they could be employed in the mid-1990s. DOE expects that using these new techniques could reduce uranium ore requirements by as much as 20 percent.

Generally, we found that while the improved uranium enrichment techniques may be technically achievable, they are now at such an early stage of development that their projected contribution by the mid-1990's can only be viewed as highly uncertain. The DOE officials responsible for this program told us that the technology as it presently stands is not sufficiently mature either scientifically or from an engineering point of view to consider it as a replacement for DOE's current gaseous diffusion enrichment program. The recently completed NASAP study reached the same conclusion while also noting that acceptance of the new technology could be constrained by proliferation and economical considerations.

UNANTICIPATED EVENTS COULD INCREASE DEMAND FOR NUCLEAR POWER

Assumptions about the future growth of nuclear power is another key factor the administration has used in determining the need for and timing of the breeder reactor. Unfortunately, projections of future nuclear generating capacity are also subject to considerable uncertainty. Past projections of nuclear growth have proven to be overly optimistic and in recent years the estimates have continually declined. DOE and administration officials have cited these declines in nuclear electricity projections as part of the justification for delaying the development and demonstration of the breeder reactor. To further support this contention, DOE has chosen as its latest nuclear projections estimates that are lower than those estimated by other knowledgeable sources. These projections are based only on reactors that are operating, under construction, or on order and not on the amount of nuclear power the United States may need to meet future energy demand. Further, DOE's analyses have failed to recognize several unanticipated events that could reverse nuclear's downward trend. Again, DOE has not chosen the more conservative planning estimates as its nuclear energy planning base.

The uncertainty of nuclear energy supply forecasts can be illustrated by how often and how significantly they are adjusted. Historically, nuclear energy growth forecasts have been overly optimistic. In January 1977, DOE forecasted that about 1,000 reactors, or 600 gigawatts 1/ of electricity, would be needed by the year 2000 to meet expected electrical energy demands. In April 1978, this estimate was revised downward to between 255 and 295 gigawatts by the year 2000. The latest DOE forecasts for the year 2000 is for 200 to 240 gigawatts or a median of 220 gigawatts. This median is approximately one third of that estimated just 3 years before. Similarly, the nuclear projections prepared by other reputable analysts have also declined. Recent projections and market surveys performed by nuclear reactor vendors predict a range of between 200 and 300 gigawatts of nuclear capacity in the year 2000.

On the surface, these declines in nuclear growth forecasts would support DOE's contention of diminished nuclear energy growth for the future. However, the analyses perfomed by DOE and others, including NASAP, do not factor in several unanticipated events that could have a significant effect on future nuclear energy growth. For example, DOE's estimates are now based primarily on reactors either on order or under construction and not on the amount of nuclear power the United States may need to meet future energy demand. In this context, DOE analyses have failed to consider the effects of a loss of access to Perisan Gulf oil, future constraints on the domestic coal supply, and limits to new hydroelectric and geothermal generating sites.

Furthermore, the future need for nuclear power over the next several decades is directly affected by the rate of development of other competing long-term energy supply alternatives. Currently there are four of these--geothermal, solar, fusion, and coal. In addition to the nuclear fuel cycle with a breeder reactor, all of these, except for coal, are viewed as "inexhaustible" energy sources. During the last 3 years, we have reviewed each of these other alternatives. Our reports have concluded that:

--Geothermal resources development has proceeded slowly in this country and can only make a limited

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1/A gigawatt is equal to one billion watts.

contribution toward meeting U.S. energy needs until numerous technical, economic, environmental, and institutional obstacles and uncertainties can be resolved. In fact, it is doubtful that geothermal resources will even attain DOE's projected energy supply goals by the year 1985. 1/

--It is uncertain that solar energy will attain the President's established goal of meeting 20 percent of the Nation's energy needs by the year 2000. At this time, DOE does not have a comprehensive plan for meeting this goal and several key elements crucial to the program's success have not yet been established. 2/

--Fusion energy is still in the early stages of research and it is, therefore, premature to assume that all of the problems to be encountered have been identified. Fusion is a long-term energy option and should not be looked to as a means for solving the Nation's near or mid-term energy problems. If all existing problems are resolved, DOE optimistically projects that fusion power could be available in the 2nd quarter of the 21st century. 3/

--Although coal is our most abundant natural resouce, it is unlikely that production will increase at the rate the administration has projected because of economic uncertainties and basic institutional and environmental problems. 4/

If problems arise in developing the other alternatives, which is quite possible as demonstrated by our recent reports, breeder reactors may have to play a larger role in this Nation's future than is currently anticipated.

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

2/"20-Percent Solar Energy Goal--Is There a Plan to Attain It?" U.S. General Accounting Office, EMD-80-64, Mar. 31, 1980.

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

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

BREEDER ECONOMICS ARE DIFFICULT TO ACCURATELY PROJECT

Breeder economics is a key variable to be considered by nuclear utilities in deciding when the LMFBR will become commercially viable. Current analyses show that breeder reactors are not now economical and will not become so for at least the next two decades. However, analyses of future economics of any long-term energy alternative are difficult to make and should be recognized as only projections based on current knowledge. Making accurate cost projections a few years in the future is difficult; making accurate cost projections a few decades in the future is nearly impossible.

Considerable disagreement exists on what it will cost to build a commercial breeder reactor. In NASAP's recent analysis, capital costs were estimated to be 25 to 50 percent higher than those of the light water reactors. DOE's nuclear strategy paper includes estimates of capital cost ranging from 25 percent to 75 percent higher than light water reactors. In addition to higher capital costs, the breeders would incur fuel reprocessing and refabrication costs not incurred by light water reactors. Some of these costs, however, can be offset by reduced enrichment costs and credits from the eventual production of surplus fissile material that could be used in other reactors. Even so, most studies conclude that LMFBRs would not become economically attractive until after the turn of the century.

In addition to the capital costs associated with plant construction, however, the economic attractiveness of commercial LMFBRs is dependent on the rate of uranium consumption, the future price of uranium, and the growth rate of nuclear power. Thus, the economic attractiveness varies depending on the assumptions made about the amount of uranium resources available, how efficiently they are used, how much LMFBR construction costs prove to be, and the growth rate of nuclear power in this country. Any conclusion about the economics of breeder reactors is directly related to the assumptions that are made regarding each of these factors and, as discussed in the previous sections, DOE has not taken a conservative approach in making several of these assumptions.

BREEDER SAFETY vs. LIGHT WATER REACTOR SAFETY IS NOT CLEAR-CUT

Two years after its policy announcement on breeder reactors, the administration chose to highlight LMFBR safety as a particularly troublesome issue. In a report to the Congress, 1/ it concluded that LMFBR technology presented greater safety challenges than conventional light water reactors. The administration's position, however, was not supported by DOE or NRC safety officials. Although both systems present unique safety challenges, it is not apparent that either system presents more or less of a safety risk than the other. In an earlier report, 2/ we commented on the document's presentation of LMFBR safety issues and generally concluded that it was unbalanced, and in some cases, factually inaccurate.

We also discussed breeder safety with DOE's program officials who told us that they did not agree that the LMFBR has inherent safety problems. In fact, prior to release of the White House Paper, DOE program officials stated in a memo that: "The argument that CRBR should be terminated for safety reasons (among other reasons) cannot be sustained on technical grounds."

Further, we interviewed knowledgeable industry, Government, and private individuals on this subject, including NRC's Director of Reactor Safety Research, and found the general consensus to be that LMFBRs and LWRs each present different safety challenges, but neither can be considered generically more nor less safe than the other.

1/"The Clinch River Breeder Reactor Project--An End to the Impasse," White House Paper, May 1979.

2/"Comments on the Administration's White Paper: "The Clinch River Breeder Reactor Project--An End to The Impasse," U.S. General Accounting Office, EMD-79-89, July 10, 1979.

CHAPTER 3

THE U.S. LMFBR PROGRAM

NEEDS DIRECTION

Regardless of the validity of the administration's contention that commercial LMFBRs will not be needed before the year 2020, our review of the structure and pace of the program disclosed that the United States may not even be able to meet this date.

While there is a considerable degree of agreement about the need for this country to pursue a vigorous program of breeder research and development so that the LMFBR option can be commercially available if and when needed, considerable disagreement exists on how to best reach that goal. To date, no clear consensus has emerged among the Congress, the administration, environmental groups, public interest organizations, the nuclear industry, and public utility interests on how best to proceed with the program.

As a result of this controversy and the uncertainty about the LMFBR's future, the LMFBR program that has evolved from the administration's revised program strategy is in disarray. The current structure and pace of the program may not permit the United States the option of deploying the technology if and when it is required to meet national energy needs. Specifically, the current LMFBR program

--lacks a clear mission and focus that could result in a considerable waste of money and time, and

--does not include assurance that the requisite institutional conditions for commercializing the option--industrial capability and utility confidence--will be in place to allow for a smooth transition to this energy supply option if and when it is needed.

THE PROGRAM NEEDS A MISSION AND FOCUS

While the administration has endorsed a major role for nuclear power in the Nation's energy future, including the retention of a breeder option, it has also embarked on a program to slow the pace of breeder reactor development. To implement this strategy, DOE was directed, among other things, to terminate the CRBR plant project and to indefinitely defer the demonstration phase of the LMFBR program. Further, driven by its non-proliferation concerns, the administration decided to take advantage of the delay in the breeder development schedule and expand the research and development phase of the program by emphasizing the need to study alternative nuclear fuels and fuel cycles that may offer nonproliferation advantages over the plutonium/uranium cycle used in LMFBRS. Accordingly, the base research and development program was reoriented toward achieving this objective.

Reorientation of the program to eliminate any work on specific LMFBR plants, however, is resulting in considerable amounts of money being spent doing research for its own sake with no particular end use envisioned for the information that is developed. As a result, the program is in danger of evolving into a make-work program for the national laboratories and industrial contractors working on it. The overall plan and focus for the program has been replaced essentially by an information gathering exercise of little demonstrable value in securing a long-term nuclear energy supply option in this country.

In our opinion, the source of this problem is the absence of two essential program elements:

--For the long term, a comprehensive technology development and deployment plan outlining how the United States is to secure the LMFBR energy supply option; and

--For the short term, a specific commitment to building a demonstration plant which would provide needed fabrication, construction, and operating experience to direct the base technology work now being done by DOE's laboratories and contractors.

Need for a comprehensive technology development plan

The disagreement that has characterized the LMFBR program for the past 3 years has made planning and directing the program difficult for DOE. While a compromise on how best to proceed with the LMFBR program is being pursued by the Congress and the administration, the objectives of the program have changed from year to year. Under these circumstances, DOE's task of planning for the timely development of the LMFBR technology has become quite difficult. This lack of consensus and clear guidance has precluded the DOE program managers from gaining approval and support in developing a coherent, comprehensive plan on how this Nation should achieve the timely availability of an LMFBR energy supply option. Accordingly, no official overall LMFBR program plan exists that details an LMFBR development strategy.

After three decades and 5 billion dollars of research and development on this energy system, DOE officials were unable to provide us with a plan for how they are going to secure the LMFBR option by the year 2020 even though they recognize the need to have such a plan. Plans have been prepared within DOE on how to proceed with the program, but since 1977 none of them have been approved or supported by the administration. Consequently, no accepted plan exists to direct the program.

The value of this essential management tool has long been acknowledged by DOE, NASA, and other government agencies involved in long-term technology development projects and has been routinely used by them in programs like nuclear fusion and the moon-shot efforts of the 1960s. Without such a "roadmap," there is no way of seeing where the program should be at a given point in time and no way of measuring progress in reaching established goals and milestones. Without these essential elements, a program cannot be effectively managed.

For example, under DOE's management structure, the research and development work done at its laboratories and contractors in support of the LMFBR program is to be guided by the budgetary and scheduling constraints placed on them by the responsible DOE headquarters organization--the Division of Reactor Research and Technology. In this context, the Division of Reactor Research and Technology should provide the laboratories and contractors with an overall technology development program plan delineating the major long-range and short-range program responsibilities, goals, schedules, and priorities. DOE, laboratory, and contractor officials acknowledged, however, that they have not been provided an overall plan to direct their work or establish meaningful milestones. Further, they do not believe there is a (1) clearly defined overall program objective or mission or (2) delineation of key program priorities in conformance with the program schedule and objectives. This situation has fostered a great deal of uncertainty and confusion among those working on the program.

Without a basic planning document from top level administrators, piecing together a program that must integrate the work plans and schedules of five LMFBR technology areas--fuels, materials and chemistry, physics, safety, and components--is virtually impossible. Moreover, the lack of a program plan severely impedes effective coordination of these five areas. The result is that the opportunity for unnecessary and costly overlaps and planning gaps in the overall program is greatly increased. This is especially true since work in these five technology areas is divided among 10 major laboratories and dozens of contractors working on the program.

For example, Argonne National Laboratory is responsible for ensuring that reactor components are constructed and available for use when needed. To be useful to the overall LMFBR program, reactor hardware schedules must be coordinated with the schedules and needs of other areas of technology development and with reactor plant construction schedules. Since no overall program plan exists, reactor hardware development is not being coordinated with other laboratory and contractor locations across the country, and consequently, components are being produced without a specific demonstration project to apply them to. This is particularly significant since individual reactor components are of little value unless they can be brought together and tested in an operating facility.

Need for a Specific Plant Commitment to Focus Ongoing R&D Effort

Not having a comprehensive LMFBR development plan reflects the long-term uncertainties underlying the eventual energy supply mission of this technology. However, the more immediate problem facing DOE is the lack of a specific plant commitment that would serve to focus the base technology research and development work being done at its laboratory and contractor facilities toward some definable and measurable end use. Before 1977, the CRBR was to be the first demonstration plant and, essentially, this commitment drove the other elements of the LMFBR program. With the uncertainty surrounding the CRBR, however, and the lack of an administration commitment to building it or another demonstration plant, the LMFBR program has become unstructured and program progress is becoming increasingly difficult to define and measure.

The political stalemate over CRBR that has been going on now for over 3 years has created a basic uncertainty among those responsible for managing the program. Congress has continued funding CRBR each year since 1977, despite the administration's repeated attempts to kill the project. Even with continued funding, however, no work has begun on plant construction. Moreover, several recent actions by the administration appear to underscore its desire to kill CRBR and to defer any commitment to build a substitute plant. Specifically

--the fiscal year 1981 budget submitted to the Congress again calls for termination of the CRBR;

--the NRC licensing staff that is necessary for the CRBR to move toward construction has been dispersed;

--the fiscal year 1981 budget is requesting that NRC's LMFBR safety research program be terminated; a move that, according to NRC, could cost the LMFBR program about 10 years of development time if or when work is resumed; and

--a decision on whether to construct a substitute plant for the CRBR facility, scheduled for March 1981, has not been supported in the administration's fiscal year 1981 budget request.

Under these circumstances, it is very possible, indeed probable, that a compromise on whether to build CRBR or proceed with plans for building a substitute plan will not be reached and another year of indecision will be facing the program. Thus, the program will again be left with no central organizing principle toward which the underlying base technology can be directed. In this regard, on October 16, 1979, a memo from a DOE Assistant Secretary to the Secretary of DOE noted that if the administration and the Congress can reach an acceptable compromise on whether to proceed with the CRBR plant or substitute another plant "* * * the advantages are clear * * * the U.S. breeder program gains a clear mission and focus."

To demonstrate the effects of this impasse on the management of DOE's LMFBR program, we reviewed the work currently being done in support of the effort at the key national laboratories and industrial contractors. We found that the supporting technology development program has largely degenerated into a basic research and development effort that has become an exercise in gathering data of little value to the program.

According to DOE officials, without a specific plant design, and the technical specifications and systems design engineering that goes with it, program managers cannot measure the value of the work being done in the base technology program areas. Under these conditions, the technology development program suffers because the definition of research and development needs cannot be as specific and detailed as when they are focused on an actual plant project. One official at a major DOE laboratory estimated that without a specific plant to keep the technology moving forward, DOE would be doing quite well if 40 percent of the information generated by such an effort is useful. This position was endorsed by most of the other laboratory, industrial, utility, and DOE officials we interviewed. This situation is exemplified by the stated objective for the fiscal year 1981 LMFBR program and DOE's comments on it. According to DOE's Fission Energy Program for fiscal year 1981, the objective of the LMFBR program is "to maintain a resource of technology information on the LMFBR concept at a level sufficient to provide the basis for a future decision on whether to proceed with further plant development and deployment." However, DOE headquarters officials informed us that it is difficult to say what information will be needed or when it will be needed.

In our discussion with DOE headquarters and laboratory officials we found several examples that we believe illustrate the effects of this situation on the LMFBR base program activities.

Laboratory officials told us that without specific plant requirements, their work has become generic in nature and consequently the focus of the work is lost. Under such circumstances, many more tests and experiments must be run than if it were focused on investigating design and equipment characteristics for a specific plant. For example, laboratory officials told us the testing of fuel characteristics under certain operating conditions should clearly be plant specific, but is currently being performed under a generic approach because there is no specific plant and thus no specific fuel requirements directing the work. Laboratory officials acknowledged that without the focus of a specific fuel type, the program is much more expensive and less useful than would otherwise be the case.

We found further evidence of this in the work being done on LMFBR components development. Laboratory officials told us that without a specific plant design, including detailed component technical specifications, the program is operating "on its own." In this regard, they told us they were doing component research and development on pieces of plant hardware they "think" will ultimately be needed for a large component fabrication capability in private industry. According to these officials, recent work has been generic in nature and has not been directed toward any specific piece of reactor hardware. As a result, the component development program may or may not produce LMFBR components that can be used in the reactors that will ultimately be commercialized. Accordingly, there is no way of measuring the results of the work being done, and thus, whether safe, reliable components are being produced.

Also, this type of unfocused research and development effort will not provide the information feedback to those developing the technology that would be supplied by the construction and operation of a LMFBR plant. Problems identified when all aspects of the technology are pulled together in a real operating plant must be factored into the base research and development work in order to fully identify problems and better understand the technology. Without a specific plant, these kinds of problems may not become apparent until a later, more time-critical date. The result is a diffuse, disoriented program which may fail to provide the kind of comprehensive and sound technological footing needed to establish and substantiate the LMFBR as a viable energy option.

UTILITY CONFIDENCE AND INDUSTRIAL SUPPORT ARE ERODING

The interests, views, and needs of the electric utility industry and the industrial suppliers (reactor manufacturers and vendors) are key perspectives that must be factored into any energy supply strategy. Without the support of both of these groups, no technology could be effectively turned over to the private sector. While the current objective of the LMFBR program does not explicitly include commercialization of the technology, the development of a valid energy option must include assurances that there is a utility sector desiring to buy LMFBRs and reactor manufacturers willing to sell them.

Our review showed, however, that neither of these institutional prerequisites--utility confidence or industrial support--has been adequately factored into DOE's current LMFBR program. To the contrary, we found that utility companies are losing confidence in the program's ability to produce an acceptable energy supply alternative and the industrial support that has grown up as part of the CRBR activity is beginning to deteriorate.

Erosion of utility confidence

The confidence of the utility industry in this Nation's commitment and capability to build and deploy LMFBRs has been badly shaken by the administration's program redirection and subsequent program changes. Until 1977, the LMFBR development program was aggressively pursued with utilities to ensure that it would lead to a safe, economic, and reliable LMFBR plant; one that utilities would buy. At that time utilities were integrally involved in all phases of the program including the CRBR demonstration plant project. In contrast, under DOE's current approach to the program, which includes preparing a conceptual design for a larger LMFBR plant, no such coordination with the utilities exists. In fact, utility involvement is conspicuously absent from the current program despite the administration's statements (1) endorsing a major role for nuclear energy in meeting the Nation's electrical energy needs and (2) promising the maintenance of a strong, well-funded LMFBR base technology program.

The lack of utility involvement in the conceptual design study could lead to a plant design that is unacceptable to the needs of the utilities. For instance, the design that has emerged from the conceptual design study includes provisions for a 14-month long nuclear core refueling cycle. According to several utility executives we contacted, however, such a design would not serve utility interests because they prefer to reload the core every 6 or 12 months--the spring and fall seasons of each year when demand is low.

Furthermore, two of the major factors in a utility's decision to purchase any reactor, including an LMFBR, is its cost and reliability. In this regard, DOE, national laboratory, and utility officials told us that the only way to obtain accurate plant cost and reliability data is through the actual operation of LMFBR demonstration plants. As it is, the administration's program has no clear commitment to a plant or a schedule that will provide this kind of data to the utilities, plant designers, or planners. Yet, interestingly, the Environmental Impact Statement on the LMFBR program was predicated on the need to build facilities that would demonstrate these characteristics to utilities. Accordingly, because it is unclear that CRBR will be built and because there are no firm plans for building any other LMFBR plant, needed answers to essential utility questions are not provided for in the present program.

To substantiate this point, we asked the chief executive officers of 19 of the Nation's largest utilities to give us their views on the current LMFBR program. Sixteen 1/ of them replied. Their comments are summarized below:

--The utilities unanimously opposed terminating CRBR and substituting a conceptual design study for it.

1/Two utilities did not reply and the Chairman of the Tennessee Valley Authority declined to comment in view of the administration's ongoing debate with the Congress over the LMFBR.

--With only one exception, the utilities objected to scaling up to a large plant without the benefit of construction, licensing, and operating experience from an intermediate-sized plant such as the CRBR.

--The utilities saw some value in building a "licensable" 1/ but unlicensed plant based on the conceptual design study to get it on line earlier, but believed such a course of action could cause more problems in the long term if commercial LMFBRs are built.

--The utilities were generally still interested in LMFBRs but were hesitant to participate financially in its development unless they received assurances that a development program would be maintained and the Government would not back out again as it is attempting to do on CRBR.

Much of the utilities objections to terminating CRBR and substituting a plant based on the conceptual design study stem from their suspicion that the study will never go beyond a paper exercise and will not result in a plant being built. They believe that building and operating an LMFBR is imperative because it would provide them valuable information on licensing needs, construction costs and schedules, and operating costs. Completing the CRBR, even though it is relatively small and possibly not as advanced as foreign LMFBRs, would give them much of the information they need; whereas a paper study such as the conceptual design will not unless a decision is made to actually construct it. We found the utilities concerns to have some validity. Since we spoke to these individuals, DOE officials told us that the administration currently has no plans to construct a facility based on the current design study no matter what happens on the CRBR impasse.

Also, the utilities are very concerned that there is a high plant reliability risk involved in jumping to a large, 1,000 megawatt size plant based on the conceptual design study without the benefit of operating an intermediate size plant like the CRBR, which is about 2-1/2 times smaller. According to almost all of the utility executives we contacted, past experiences have shown that larger plants tend to produce larger problems. To them, a smaller scale demonstration

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1/As the term is used here, a "licensable" plant is one that would be subjected to an NRC safety review but would not be subjected to a public hearing process as are fully licensed plants.

under utility operating conditions is considered vitally important. Furthermore, they believe that a plant based on the design study, which will probably be built on a Government reservation, operated by Government technicians in a nonutility atmosphere, and may not be licensed, would not provide a useful or realistic demonstration of LMFBRs to the utilities.

The utilities expressed particularly strong concern about the possibility that the conceptually designed plant, if built, may not be licensed. Generally, they agreed that if the plant were subjected only to an NRC safety review without going through the entire licensing process, it may begin operation earlier. In their view, however, such a course of action would create more licensing problems later when the first commercial plant is built and must undergo a full NRC licensing review. As a result, they generally favored a full-licensing review of any LMFBR demonstration plant. None of the utilities are willing to take the next step of building the first commercial plant and fighting it through the licensing process without a licensed demonstration plant to refer to and rely on. NRC representatives also saw no advantage to be gained by not licensing a plant that might be built as a result of the current DOE conceptual design study. They said that putting off licensing could only make the problem of licensing subsequent commercial plants worse because different requirements might be imposed and there would be no established precedent to fall back on.

The effect of all these concerns is that while the utilities are still interested in continuing participation in LMFBR development, they are hesitant to participate financially unless they have assurances the Government will continue the program. The utilities have invested about $100 million in CRBR and an additional $150 million is being held in escrow, the benefits of which may be lost to them if the CRBR is terminated. They do not want this to happen to them again.

Deteriorating industrial infrastructure

The industrial infrastructure underlying the LMFBR program, which has been put together over the last 30 years, is starting to come apart as a result of the administration-imposed hiatus on completing CRBR and failure to make a commitment to building a larger LMFBR plant. Top quality people are quitting because they see no future in LMFBRs, are retiring or approaching retirement, or are being dismissed because of declining LMFBR work.

Reactor manufacturers and the vendors are closing facilities or redirecting them to other purposes because there is not sufficient business, or promise of it, to keep the facilities available to support the LMFBR program.

A former Assistant Secretary of DOE told us that the administration's decisions have put the LMFBR program in disarray. He stated that the LMFBR infrastructure which has been put together will disappear if no commitment is made to build and operate LMFBRs soon. An official of a utility research organization agreed, and estimated that it will occur in about another 4 years if the present inaction on building LMFBRs continues.

Utility, reactor manufacturer, DOE, national laboratory, and other officials told us the loss of quality professional and technical people was the largest threat to maintaining the LMFBR option. Once this happens, they believe it will be impossible to resume the Nation's nuclear program in a reasonable time frame. In fact, DOE contends that the LMFBR energy supply option will be lost for the foreseeable future.

The administration's strategy of terminating the CRBR plant and deferring a decision on a substitute facility, could very well necessitate the demobilization of the design and manufacturing capability that has been built up over the past three decades in support of this program. If this happens, the engineering personnel with detailed knowledge of LMFBR plant design and component manufacturing would be lost. And, it could take as long as 5 years to get the necessary talent and expertise reassembled. One of DOE's chief nuclear policy analysts told us that while DOE recognizes this possibility and its ramifications, they would rather confront the problem later, not now.

For example, the lead reactor manufacturer on the CRBR facility told us that without a commitment to build a follow-on plant soon, there will not be enough work to keep engineering personnel productively working. This may irrevocably cost the industry about one-half of its engineering base capable of supporting the LMFBR program. The reactor manufacturer said the engineers would be transferred to other more productive areas within the company, or they will move to other companies in the industry. Because there is no large, experienced talent pool of engineers for the specialized LMFBR work as there was for the aerospace and electronics industries in the early 1970s, the loss of experienced talent will cost the LMFBR program considerable time and money.

Officials at Argonne National Laboratory told us that if the LMFBR program "hibernates" for a few years, it will be necessary to close many test facilities. This will result in laying-off skilled people and, if it is decided to restart the program, it will cost the program 5 to 10 years to reassemble the type and amount of talent they now have. Officials at other national laboratories we visited generally agreed with this assessment.

DOE officials acknowledged that high quality technical personnel are leaving the program, and that they are having a difficult time attracting new, young talented people. They are especially concerned about the inability to attract new, young people because they foresee many of their best experts retiring in the next few years. Many of their most knowledgeable people have been in the LMFBR program since its inception--about 30 years. Because of the frustrations and disappointments these people have experienced in the past several years, it is doubtful that they would be motivated to extend past their retirement eligibility.

Further, as part of the fiscal year 1981 budget request, the administration has proposed that NRC's safety research on LMFBR's be terminated. Under this program, NRC conducts independent safety research on LMFBR technology to develop valid licensing standards for eventual use in commercial plants. But, the administration's fiscal year 1981 budget request, if accepted by the Congress, will prevent this objective from being met for many years. In fact, NRC officials told the Congress that it would take 10 years to pick up this program again if it is terminated. It is difficult to justify such an action, unless no LMFBR plant is planned over the next 10 years. The implications of this for maintaining the necessary technical expertise and knowledge that has grown up in support of the LMFBR programs are obvious--they will be lost.

In addition to losing technical personnel valuable to the LMFBR program, the continued delay in the program is resulting in a loss of manufacturing capability. With no prospect of an LMFBR plant in the near future and the work on CRBR essentially completed, many of the vendors who supplied components for CRBR have gotten out or are getting out of the LMFBR business. We identified 11 vendors who refused to bid on any more CRBR work and 17 others that may also be getting out of the nuclear business. In addition, six companies are closing their LMFBR component divisions.

In short, the cyclical mobilization and demobilization of design teams and manufacturing capability that will be required under the current approach to the program will result in major discontinuities in the timely development of the LMFBR energy option. There is no telling how many years this could cost the program.

CHAPTER 4

DOE'S DECISION TO TERMINATE THE GAS-COOLED BREEDER REACTOR PROGRAM IS PREMATURE

Very early in the U.S. breeder reactor technology program the United States recognized that unforeseen technical and institutional obstacles could arise that would prevent LMFBRs from becoming this country's primary nuclear energy supply system. Accordingly, DOE and its predecessors proceeded cautiously by chosing to develop other breeder concepts in addition to the LMFBR. The logic was obvious, if the primary technology development program failed, a backup technology would be available for further development. This fall-back capability was to assure a higher probability of commercial success for the breeder development program.

In pursuit of this strategy, DOE has been developing two alternate breeder concepts--the Light Water Breeder Reactor (LWBR) and the Gas-Cooled Fast Breeder Reactor (GCFR). While neither concept has received the degree of funding support accorded the LMFBR, the LWBR technology is being demonstrated in a small reactor facility and the GCFR technology is still being studied. However, the administration's fiscal year 1981 budget calls for termination of the GCFR program, while continuing the LWBR. Consequently, the heir-apparent program to current LWRs--breeder reactors--is apparently left with a single backup technology should the LMFBR program fail. But, according to DOE officials, the LWBR is not viewed as an alternative or backup to LMFBRs because its objective and purpose are different than either the LMFBR or GCFR reactor systems. The LWBR, although called a "breeder" reactor, is only a self-sustaining reactor system. Its purpose is to produce enough fuel during its operation to be able to refuel itself; not provide fuel for other reactors as would the LMFBR and GCFR. Further, the LWBR uses thorium as a fuel, rather than plutonium, and is therefore viewed as another alternative energy supply source to be developed independent of the LMFBR. Consequently, even if the LWBR achieves its objectives it is not viewed as a replacement for either LMFBRs or GCFRs as net fuel producers in this country's future energy mix.

Because the LWBR program is a rather unique program within DOE, we are now doing a separate review of it. The review will assess the scope, merits, and role of the LWBR concept in DOE's nuclear energy development program. Accordingly, this particular program is not discussed any further in this report.

So, since the LWBR is not considered as a backup to the LMFBR, we reviewed the basis for and impact of DOE's decision not to support GCFR technology to see if it is a sound and reasonable one. This decision, in effect, left the breeder reactor program without a backup technology in the event the LMFBR should fail. We found that enough risks concerning the development of the LMFBR technology remain that a backup system is still justified. Accordingly, the potential benefits of the GCFR concept merit continuation of the program at least to the point where a decision has to be made on whether a demonstration plant should be built. Consequently, we believe that DOE's decision is premature.

PROGRAM STATUS AND OBJECTIVES

The GCFR, like other fast breeder reactor concepts, is designed to produce more fuel than it consumes. It can be operated in a breeder-only mode to furnish fuel for other reactors, or in a combined mode of producing fuel and generating electricity. Currently, the GCFR's unique characteristics stem principally from the use of high pressure helium gas as the reactor coolant instead of water or liquid sodium.

As a backup to the LMFBR technology, GCFRs are at least 5 years behind LMFBRs. The key projects and developmental tasks in support of the GCFR program have been timed and funded to correspond to a 30-year commercial deployment schedule. The development of the technology is being pursued in two discrete phases. It is now in the first phase which is the program definition and licensing phase. This phase was to provide (1) completion of research and development for basic engineering, (2) a high confidence cost estimate for a development plant based on completion of 70 percent of the engineering, and (3) assurance of licensability. It was to end in 1984 when a decision would be required on whether to continue the program by building a demonstration facility.

The technology is being developed by a partnership of DOE, U.S. utilities, and industry through their participation in the Helium Breeder Association and several foreign nations. DOE's involvement has been to provide overall direction to the program, oversee the implementation of it, and to provide funding support. From 1963 through fiscal year 1980, DOE will have provided about 50 percent of the funding needed to support the program. The other half of the money has come from 73 domestic utility and industrial participants and several foreign nations. However, plans called for DOE to provide about 75 percent of the funds needed to complete phase one of the program which would be about $218 million through fiscal year 1984.

Now, however, DOE has decided to terminate its participation in the program. As a result, the fiscal year 1981 budget request has eliminated continued funding for GCFR development. DOE officials have cited four basic reasons for its decision: (1) its judgment that a backup breeder technology is no longer needed, (2) unproven and distant incentives, (3) the lack of a qualitative nonproliferation advantage, and (4) the need for experimental resolution of key safety and heat transfer issues before a commitment to a demonstration plant could be made.

THE GCFR HAS SEVERAL POTENTIAL BENEFITS

The support for the GCFR program is based on several potential benefits. The principal ones are (1) a higher fuel breeding ratio, (2) lower capital costs, (3) improved maintenance characteristics, and (4) relatively low development costs.

The promise of higher fuel breeding performance for GCFRs in relation to other breeder concepts is widely recognized as a major potential benefit of this particular reactor system. We spoke to knowledgeable scientists, engineers, and academicians on this point and very few of them disputed this aspect of GCFR operation. While superior breeding performance is not of immediate value, it will be of greater importance if U.S. reliance on nuclear power continues to grow, uranium supplies dwindle and growth of electricity generation becomes increasingly more dependent on fuel provided by the breeders. Also, a higher breeding performance would mean that fewer reactors would be needed.

The GCFR also offers the potential of lower capital costs since it does not require all of the heat transfer components of LMFBRs. This significantly reduces requirements for stainless steel and allows for more compact plant systems. The General Atomics Company, a major nuclear plant manufacturer, estimates that a LMFBR plant will cost about 15 percent more than a GCFR plant of similar size but cautioned that the capital cost benefits cannot be verified until a number of reactors have been commercially deployed.

Further, the use of helium gas as a coolant has the potential to improve the maintenance characteristics of a breeder reactor. For example, maintenance access problems tend to be miminized because the helium is not radioactive, and visual inspection of the primary cooling system components is possible since helium is transparent.

Finally, the GCFR development program has been tailored to make maximum use of technology already developed or under development in the LMFBR and high temperature gas-cooled reactor 1/ programs. For example, the GCFR core closely resembles its LMFBR counterpart and uses the same fuel, cladding, and duct material. Other benefits the GCFR system derives from the LMFBR program include experience with licensing procedures; plant operating experience; advanced materials design, engineering, fabrication and maintenance capabilities; and existing engineering codes and standards. In addition, it can largely be supported by the industrial infrastructure that has been developed in support of the LMFBR program. The GCFR program also benefits from high temperature gas-cooled technology because the design of the plant and reactor system adopts technology which has already been demonstrated in an operating commercial gas-cooled reactor in Colorado.

Although the GCFR does have several significant benefits, the GCFR also has several drawbacks. For instance, some key safety and heat transfer issues of this technology have to be resolved, some of the potential advantages have yet to be proven, and there is no clear proliferation advantage to moving to this concept.

DOE'S DECISION TO TERMINATE ITS PARTICIPATION IN THE PROGRAM WILL TAKE AWAY THE ONLY BACKUP TO LMFBRs

If the fiscal year 1981 GCFR budget request is approved by the Congress and DOE's participation in the program is terminated, the supporting industrial infrastructure will probably collapse and the only nuclear alternative the LMFBR technology will be lost. The GCFR concept is being developed by DOE, national laboratories, utility companies,

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1/The High Temperature Gas-Cooled reactor is a nuclear generating system that does not breed fuel but uses it more efficiently than conventional LWR plants. This kind of system is known as an advanced convertor reactor system. Like the GCFR this system is also helium-cooled.

commercial industrial companies and engineering firms, and foreign nations. DOE officials told us that if fiscal year 1981 DOE funds are terminated, the DOE headquarters and national laboratory staff, as well as contractors' staffs working on the GCFR program, will be released, and the equipment and supplies will be stored away, cannibalized, or disposed of by some other means.

The utility companies and industrial and engineering firms involved also told us that their efforts would probably cease if DOE terminated its program. Officials of the Helium Breeder Association told us that without DOE funding, it would not be possible for them to carry out a viable program or maintain their organization's membership. And, officials of the leading industrial proponent of GCFR, the General Atomic Company, told us that if the DOE program is terminated, it is doubtful that they would continue to spend company funds to further the program.

If this country is to have a long-term nuclear power supply option, a breeder reactor is essential. In fact, the only way a breeder reactor development program can be justified is on that basis. Accordingly, the United States has chosen the LMFBR technology to meet this national need. However, if the development of a long-term nuclear power option is a national priority, the United States cannot afford to put all of its eggs in one basket. It could prove to be very costly if the LMFBR program fails. Thus, we believe that the original justification for continuing a backup to the LMFBR is still valid. And, since the light water breeder reactors are not being developed to serve this need, the GCFR system is the only realistic alternative.

In terminating the GCFR program, DOE reasoned that the stretchout of the LMFBR program and deferred commitment to construct breeder reactor plants reduced the need for a backup system. However, the uncertainties in the LMFBR program, especially the debate on whether to construct and operate a demonstration plant could result in the LMFBR no longer being technically and economically acceptable to the public. Further, while LMFBR development is ahead of the GCFR, the successful commercialization of the LMFBR is not yet assured.

For example, in May 1979, we reported 1/ that:

--While skipping the CRBR project for a larger plant does not raise significant safety issues, the potential economic consequences and reduced public confidence in the safety of the larger plant could inhibit future efforts to commercialize LMFBR technology.

--Industry and Government sources pointed out that if the CRBR is not built, extra conservatism would have to be engineered into the next larger plant design resulting in additional safety features, more stringently designed hardware, and more conservative operating procedures, all of which add costs to the project.

--These sources also believed the large plant would likely experience more component failures and operating problems that could seriously affect the econmic success of the project.

If events follow this course, the need for a backup program is evident. Without an alternate, an earlier than anticipated need for a commercial breeder reactor would force the United States to an accelerated program with attendant costs and risks, or to turn to foreign suppliers.

In this regard, we believe the several potential technical and economic benefits of the GCFR technology present a strong case in support of continuing the program as a backup breeder through its current definition and licensing phase. As a backup technology, the program would be aimed at getting a better understanding of the technology through additional research and development so that a better informed decision can be made on whether to use it if the LMFBR program does not meet its objectives. Getting answers to unresolved technical issues and getting proof that a particular reactor concept has specific advantages characterizes the nature of a backup research and development program. Moreover, the GCFR was intended to operate on the same fuel cycle as the LMFBR. Consequently, it is difficult to understand why this is posed by DOE as a disadvantage to the GCFR program and not to the LMFBR program. Also, a substantial degree of utility and industry support exists to maintain the GCFR as

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1/Report to the Congress, "The Clinch River Breeder Reactor--Should The Congress Continue to Fund It?" (EMD-79-62).

a backup breeder technology. While it is in an early stage of development, the GCFR energy system is perceived by DOE, utilities, and the nuclear industry as having the potential for both superior technical and economic performance over the LMFBR energy system. But DOE's withdrawal from participation in the development of the technology will probably terminate all domestic efforts to develop it. The result may be that the supporting industrial infrastructure will collapse and the only nuclear alternative to the LMFBR will be lost.

CHAPTER 5

CONCLUSIONS, RECOMMENDATIONS, AND

EVALUATION OF AGENCY COMMENTS

CONCLUSIONS

Over the last several years the administration has continually endorsed the need for nuclear power in helping meet U.S. energy demands and in decreasing this country's reliance on foreign oil supplies. While there is a lot of room for debate on the precise role nuclear power should play in the U.S. energy supply mix, any strategy that would rely on nuclear fission as a long-term energy source requires the use of breeder reactors. Therefore, a decision not to employ breeders implies the phasing out of nuclear fission as an energy source. Exactly when this would occur, however, depends on energy demand and the U.S. ability to recover uranium and further improve the fuel utilization efficiency of light water reactors.

If the administration's assumptions of low nuclear growth, more plentiful uranium, high capital cost, and generic LMFBR safety problems are accepted, it is difficult to argue that the development of breeder reactors in general, and of the LMFBR specifically, is an urgent task in the United States. The administration, however, has taken the most optimistic and least conservative view of these factors. In our view, faced with a 40-year time span for development of the LMFBR to a point where it could be commercially available, DOE's planning approach must allow for unexpected variations and contingencies in this country's energy supply future. In this regard, there are very plausible combinations of circumstances which favor continuation of an active breeder program in this country. These possible developments must be considered in planning a prudent nuclear development strategy. For instance, if nuclear growth begins to increase, if the amount of uranium actually found to be available is less than the administration's projections, or LWR fuel efficiency improvements aren't fully realized, significant energy supply shortfalls could result. And, unfortunately, none of these occurrences can be written off.

In our opinion, the path of breeder development called for by the current strategy is founded on speculative planning estimates and highly uncertain projections that could result in the United States being unable to respond to its energy supply needs as they arise. Further, the pace of breeder development now being pursued builds the risks of breeder development into the later stages of the program where errors in judgment or miscalculations in planning estimates can be least tolerated, rather than the more conservative approach of building these risks into the early stages of the program where the margin for error is greater because time would allow for corrective or compensatory measures to be taken.

But, regardless of the validity of the administration's rationale in reorienting this country's breeder reactor program or of the timing for commercializing the technology, the need for a well-managed and focused program on how to secure this energy supply option is essential. Yet, the administration, through its commitment to kill the first industrial-sized LMFBR demonstration facility and its reluctance to proceed with another facility, has precluded the development of this technology from moving forward.

The lack of a firm objective by committing to construct and operate an LMFBR plant has recast the U.S. LMFBR program from a technology development program into a basic research effort. Consequently, little demonstrable progress toward assuring the commercial availability of this energy source has been realized since 1977 and current attempts to pull together the more than 30 years of LMFBR technology development experience, costing nearly $5 billion, into an operating LMFBR plant, have been unsuccessful.

Moreover, the lack of a comprehensive LMFBR program plan has fostered a great deal of uncertainty and confusion among those working on the program and relegated the program to essentially an information gathering exercise. Yet, at the same time, hundreds of millions of dollars annually are being spent on it. In our opinion, this condition will exist until a clear and firm national commitment is made regarding the future role of nuclear power in this country. If the decision is that nuclear power should play a major role in this Nation's future energy supply mix, a commitment to construct and operate an industrial-size plant is needed so that DOE can proceed with a more systematic and focused research and development program.

Further, to secure the future ability to deploy the LMFBR option, several key questions on the safety, economics, and the environment will have to be resolved to the satisfaction of the public, the utilities, and the nuclear industry. The only way to adequately resolve these generic questions is to build and operate a plant. The major studies of proliferation risks of the uranium/plutonium fuel cycle have concluded that the LMFBR does not pose any more proliferation risks than do other alternative fuel cycles. Thus, in our judgment, the primary basis for the administration's deferral of the program can no longer be justified. The longer a commitment to a specific LMFBR reactor facility is delayed, the more likely it will be that pressures for hasty, ill-conceived programs will build up. Such programs may unnecessarily involve higher technological risks and compromises of national, environmental, and safety standards. Clearly, these pressures and risks could and should be avoided through the execution of a well-thought-out, deliberate research, development, and demonstration program.

Also, largely as a result of the lack of a comprehensive program plan and lack of progress toward a LMFBR demonstration facility, the necessary institutional prerequisites for securing a breeder option--utility confidence and industrial support--have not been adequately factored into DOE's program. In our opinion, the end result of this approach can only be looked upon as an obstacle that will serve to significantly impede the timely progress of LMFBR technology toward a true, commercially available alternative energy source. The net result could be that the United States will not have commercially available fast breeder technology if and when it is needed.

In addition, to the extent the Congress wants to rely on nuclear power as a long-term energy supply source or wants to maintain a long-term nuclear option, prudent management dictates that a backup technology be available for timely development in case the LMFBR program does not meet its objectives. The gas-cooled breeder program could provide this needed backup capability. Consequently, the program should continue at least until it reaches a decision point on whether to construct and operate a demonstration facility--now scheduled for about 1984.

RECOMMENDATIONS TO THE CONGRESS

Over the past several years both Congress and the administration have endorsed the need for maintaining a strong LMFBR program in this country. However, as this report demonstrates, a strong LMFBR program includes the construction and operation of a plant. Consequently, if this country wants to rely on nuclear power as a long-term energy source or even if it chooses only to preserve a timely energy supply option for possible use if other energy technologies cannot carry the load, the information gathered by us supports the position that breeder technology should move forward to the construction and operation of a LMFBR demonstration plant. In fact, the Congress, by continuing its support to construct and operate a demonstration plant over the last 3 years, has chosen this path. In this regard, however, it should be noted that the construction and operation of a LMFBR plant that would serve to demonstrate the viability of the technology should not be viewed as an irrevocable commitment to commercially deploy the technology. This can be and should be two distinct phases of the overall development process.

In contrast, however, the administration, by its rigid opposition to the construction of any breeder plant over the next several years, has chosen a different path. So, if the program is to move forward it is necessary that the circle of debate between the Congress and the administration be broken and that a clear and firm commitment on the long-term role of nuclear power be made. Recognizing the administration's position on this matter, the only real alternative is for the Congress to shoulder this burden.

In this regard, if the Congress wishes to maintain a nuclear option or if it wishes to commit nuclear power as a long-term energy source, we recommend that it require DOE to demonstrate the viability of the LMFBR technology by mandating the construction of a breeder reactor facility no later than during its fiscal year 1982 budget deliberations. However, in making this recommendation we want to emphasize that we are not necessarily advocating the completion of the Clinch River Project as the only means of moving the program forward. The only resolution to the impasse may be to move ahead with a larger, more recent facility.

In our opinion, the imposition of a plant commitment on DOE would help foster a more appropriate U.S. breeder reactor research, development, and demonstration posture. As part of this mandate, however, 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.

Further, a commitment to a long-term nuclear option should include continued support for the gas-cooled fast breeder reactor program since it is currently the only real nuclear alternative to the LMFBR technology. Accordingly, we recommend that Congress continue to fund this program at least until the program reaches a decision point on whether to construct and operate a demonstration facility. Such an approach is essential.

On the other hand, if Congress cannot reach a resolution on whether to preserve the breeder option or if it does not wish to do, we recommend that it consider terminating the program. To continue to fund the program at several hundred million dollars a year to keep the scientific and engineering teams together is hard to justify. However, Congress should recognize that if the program is terminated it could cost the program many years of developmental time if Congress later chooses to restart it. If this were to occur, the only available alternative may be to purchase breeder reactors from some more advanced, foreign nation, most notably France.

DOE COMMENTS AND OUR EVALUATION

DOE provided us written comments on this report. And, where appropriate, we made several revisions to the report to more accurately reflect DOE's position on certain matters. This section of the report contains our response to the Department's major comments. The full text of DOE's comments is included as appendix I.

DOE comment

"We are in agreement that for management and resource effectiveness, a central organizing principle and schedule is desirable. The Department of Energy (DOE) program officials stated this repeatedly and referred to the Program Plans issued in 1968 and updated in 1973 and 1976. The fiscal year 1980 "Fission Energy Program of the U.S. Department of Energy," April 1979, DOE/ET 0089, Chapter IV, does provide a rational approach with specific goals and milestones leading to the design and construction of breeder demonstration powerplants on an orderly basis, if and when it is decided as national policy that deployment of breeders is required."

Our evaluation

We do not see this comment as being inconsistent with the text of our report. While DOE officials did repeatedly point out the existence of comprehensive program plans prior to the administration's redirection of the LMFBR program in 1977, the relevant point is that there is no officially authorized technology development plan that now exists that has the acceptance and support of the administration. Consequently, no matter how many plans DOE managers can now point to, none of them carry any weight since they have not been endorsed by the administration. The fiscal year 1980 document referred to by DOE is one of these plans. It is a plan put together by the nuclear energy group within DOE at the request of the House Committee on Science and Technology. It is not necessarily approved by the administration and in fact recent budget submissions by the administration appear to undermine the plans proposed in this document. Moreover, even this plan does not provide a "roadmap" of how this country plans to secure the LMFBR energy supply option by about the year 2020, it only covers a period of about 10 years--to 1990.

DOE comment

"The GAO report did not explain the logic for DOE's decision to terminate the Gas Cooled Fast Reactor (GCFR); namely, there was no technical need for a Liquid Metal Fast Breeder Reactor (LMFBR) backup; uncertain and distant incentives; the lack of a qualitative nonproliferation advantage; and the need for experimental resolution of key safety and heat transfer issues before a major project commitment could be made."

Our evaluation

We agree with this comment. Accordingly, the report has been revised to include an explanation of why DOE decided to terminate the GCFR program.

DOE comment

"The GAO report attempted to compare the Light Water Breeder Reactor (LWBR) and the GCFR. The staff wishes to emphasize that these two concepts are basically two different types of nuclear power plants, featuring different characteristics, operating on different fuel cycles, and under development for different roles in the nuclear power generating mix of the United States. Another significant point to note is that the LWBR fuel cycle will be available to the industry, providing an extension of the Light Water Reactor fuel utilization efficiency without the expensive and time-consuming effort of scaling up a new heat transport system. To further clarify this point, we are hereby enclosing comments prepared by Admiral H. G. Rickover."

Our evaluation

We basically disagree with the comment. While there are many differences between the GCFR and LWBR reactor systems as DOE notes, they are both nuclear breeder reactor systems that compete for nuclear breeder reactor research and development funds within DOE. Consequently, overall funding constraints affect the relative emphasis and priority received by each of these systems. Within this context, we believe a comparison of the GCFR and LWBR reactor systems is a valid one.

None the less, because the future role for LWBRs is so substantially different than that for GCFRs or even LMFBRs, we believe a more indepth study of the entire justification for the LWBR program is warranted instead of a comparative analysis as was originally included in the draft report provided to DOE for comment. So, the report has been revised to exclude the comparative analysis of the LWBR versus other breeder reactor concepts. Instead, we plan to issue a separate report on the LWBR program early in the calendar year 1981 that will evaluate the system on its own merits.

DOE comment

"We also had the benefit of the review by Office of the Assistant Secretary for Resource Applications, commenting and updating the pertinent portion of the GAO report. These comments are also enclosed for your consideration."

Our evaluation

The comments provided by the Assistant Secretary for Resource Applications were four specific points of a factual and/or clarifying nature dealing with the section on uranium availability in Chapter 2 in the report (pp. 13-17). Generally, they dealt with the accuracy of various uranium estimates and DOE's use of them. We agreed with each of the comments provided and appropriate changes were made in the report.

DOE comment

"In summary, the Reactor Program divisions are currently focusing the various LMFBR program elements through the Conceptual Design Study (CDS) and the program review process which the CDS implies by 1981. The CDS is closely integrated with the technology effort so that a state of readiness is acheived, and an industrial-scale power plant design could be initiated in 1981."

Our evaluation

While this comment is accurate, we believe there are two important points that must be considered. The first is that the CDS is only a paper study of an LMFBR plant. As such it cannot and does not provide the proper focus for the various program elements because it fails to provide specific plant design specifications nor does it provide the give and take of information and experience that is obtained through actual plant component fabrication and operation. Further, there is no way of determining what information, if any, will ultimately prove to be useful in operating LMFBR plants. It is much more of a hit or miss approach than would be the case if an actual plant were focusing the program. Secondly, while the CDS work is based upon a 1981 decision to build an industrial-sized plant, there is no indication that a decision will be forthcoming at this time. In fact, there are indications that such a decision probably will not be made. For instance, a decision on whether to construct the CDS plant has been deleted from the administration's fiscal year 1981 budget request and DOE officials have told us that the administration sees no obligation to make such a decision.

Department of Energy
Washington, D.C. 20585

JUL 28 1980

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

Dear Mr. Peach:

Thank you very much for the courtesy of sending us a draft copy of your report, "U.S. Breeder Reactor Program Needs Direction," dated July 1, 1980. We understand that a revised version of the report is in preparation, and we have not had the benefit of a review of that revised draft in preparing the comments that follow. Our cognizant program divisions reviewed the draft document and wish to make the following observations and comments.

We are in agreement that for management and resource effectiveness, a central organizing principle and schedule is desirable. The Department of Energy (DOE) program officials stated this repeatedly and referred to the Program Plans issued in 1968 and updated in 1973 and 1976. The FY 1980 "Fission Energy Program of the U.S. Department of Energy," April 1979, DOE/ET 0089, Chapter IV, does provide a rational approach with specific goals and milestones leading to the design and construction of breeder demonstration power plants on an orderly basis, if and when it is decided as national policy that deployment of breeders is required.

The GAO report did not explain the logic for DOE's decision to terminate the Gas Cooled Fast Reactor (GCFR); namely, there was no technical need for a Liquid Metal Fast Breeder Reactor (LMFBR) backup; uncertain and distant incentives; the lack of a qualitative nonproliferation advantage; and the need for experimental resolution of key safety and heat transfer issues before a major project commitment could be made.

The GAO report attempted to compare the Light Water Breeder Reactor (LWBR) and the GCFR. The staff wishes to emphasize that these two concepts are basically two different types of nuclear power plants, featuring different characteristics, operating on different fuel cycles, and under development for different roles in the nuclear power generating mix of the United States. Another significant point to note is that the LWBR fuel cycle will be available to the industry, providing an extension of the Light Water Reactor fuel utilization efficiency without the expensive and time-consuming effort of scaling up a new heat transport system. To further clarify this point, we are hereby enclosing comments prepared by Admiral H. G. Rickover.

We also had the benefit of the review by Office of the Assistant Secretary for Resource Applications, commenting and updating the pertinent portion of the GAO report. These comments are also enclosed for your consideration.

In summary, the Reactor Program divisions are currently focusing the various LMFBR program elements through the Conceptual Design Study (CDS) and the program review process which the CDS implies by 1981. The CDS is closely integrated with the technology effort so that a state of readiness is achieved, and an industrial-scale power plant design could be initiated in 1981.

Again, we appreciate this opportunity to review and comment on this in-depth study conducted by the GAO. If we can be of any further assistance, please let us know.

Sincerely,

P. Marshall Ryan
Acting Controller

2 Enclosures

List of Nuclear-Related Companies

Responding to GAO Inquiry

Nuclear Utility Companies

Alabama Power Company
Birmingham, Alabama

Arizona Public Service Company
Phoenix, Arizona

Pacific Gas and Electric Company
San Francisco, California

Florida Power Corporation
St. Petersburg, Florida

Georgia Power Company
Atlanta, Georgia

Commonwealth Edison Company
Chicago, Illinois

Consumers Power Company
Jackson, Michigan

Northern States Power Company
Minneapolis, Minnesota

Public Service Electric and Gas Company
Newark, New Jersey

Consolidated Edison
New York, New York

Carolina Power and Light Company
Raleigh, North Carolina

Philadelphia Electric Company
Philadelphia, Pennsylvania

Virginia Electric and Power Company
Richmond, Virginia

Nuclear Utility Companies (continued)

Wisconsin Electric Power Company
Milwaukee, Wisconsin

Baltimore Gas and Electric Company
Baltimore, Maryland

Arkansas Power and Light Company
Little Rock, Arkansas

Boston Edison Company
Boston, Massachusetts

Mississippi Power and Light Company
Jackson Mississippi

Tennessee Valley Authority
Knoxville, Tennessee

Reactor Manufacturers

Westinghouse Electric Corporation
Monroeville, Pennsylvania

General Electric Company
Sunnyvale, California

Architect Engineers

Burns and Roe, Inc.
Oradell, New Jersey

(302542)

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