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REPORT BY THE

Comptroller General

OF THE UNITED STATES

Analysis Of The Department Of Energy's Clinch River Breeder Reactor Cost Estimate

Much of the current congressional debate about the Clinch River Breeder Reactor (CRBR) centers around the estimated cost of designing, constructing, and operating it for a 5-year demonstration period. The Department of Energy (DOE) recently linked the revenue-generating potential of the CRBR beyond the demonstration period to the justification for continued funding.

GAO presents information that points out many uncertainties in DOE's estimates of revenue and cost. GAO believes that because these estimates are based on numerous assumptions and calculations concerning events as far as 37 years in the future, they should be viewed with caution. Changes in the underlying assumptions could produce wide variance in the cost estimates. Further, GAO points out that CRBR is a research and development project and that judging its merits solely on cost and revenue estimates projected far into the future may not be appropriate.

GAO/RCED-83-74
DECEMBER 10, 1982

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

December 10, 1982

B-164105

The Honorable John D. Dingell
Chairman, Subcommittee on
Oversight and Investigations
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

As requested in your April 28, 1982, letter, this report discusses our analysis of the Department of Energy's Clinch River Breeder Reactor Cost Estimate.

In order to provide this report in time for use during the appropriation process, we did not obtain the Department's comments. We are also providing a copy of this report today to the Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology.

Unless you publicly announce its contents earlier, we plan no further distribution until 3 days from the date of the report. At that time, we will send copies to other interested committees, members of Congress and the Department of Energy. Copies will be made available to others upon request.

Sincerely yours,

Charles A. Bowsher

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT
TO THE CHAIRMAN, SUBCOMMITTEE
ON OVERSIGHT AND INVESTIGATIONS,
HOUSE ENERGY AND COMMERCE
COMMITTEE

ANALYSIS OF THE DEPARTMENT OF ENERGY'S CLINCH RIVER BREEDER REACTOR COST ESTIMATE

D I G E S T

For several years, the Clinch River Breeder Reactor (CRBR) project has been the subject of debate within the Congress. Much of the recent debate has centered on the project's cost. The Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked GAO to review the accuracy of the Department of Energy's (DOE's) most recent cost estimate for the CRBR project.

When the CRBR project was authorized in 1970, it was estimated to cost $699 million for design, construction, and operation through a 5-year demonstration period. DOE's latest cost estimate is $3.6 billion. 1/ Of this amount, private sector participants are expected to contribute about $352 million. As of September 1982, $1.3 billion had been spent on CRBR. DOE recently interjected a new element into the discussion of CRBR's cost. In a September 1982 letter to Senator Gary W. Hart and Representative Richard L. Ottinger, DOE said that CRBR would generate more than $8 billion in net revenues over its operating life (25 years) after the 5-year demonstration period.

As of December 1982, DOE is in the process of preparing the CRBR site in Oak Ridge, Tennessee. Construction of the reactor is scheduled to start in 1984. DOE plans to start operation in 1989 and conduct a 5-year demonstration period from 1990 through 1995. The Tennessee Valley Authority (TVA) will operate the CRBR for the demonstration period.

1/All the CRBR costs are shown in current dollars. Current year dollars represent the dollar value of a good or service in terms of prices current at the time the good or service is bought or sold.

GAO/RCED-83-74
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Tear Sheet

GAO cautions that CRBR costs and revenues are based on numerous assumptions about events far into the future--as much as 37 years. The margin of error in cost estimates that contain many assumptions and that are based on future events can be significant.

GAO also believes that it is important to keep in mind that the CRBR is a research and development project. GAO believes, therefore, that projected cost and revenue estimates should not be the dominant consideration in funding decisions and that such decisions should be tempered by the recognition that cost and revenue estimates projected far in the future are subject to wide variation with changes in underlying assumptions.

UNCERTAINTIES IN DOE'S LATEST $3.6-BILLION ESTIMATE

DOE's $3.6-billion estimate essentially contains two elements--revenues that will be earned through the sale of electricity to TVA during the 5-year demonstration and the costs to design, build, and operate the project during the same period.

GAO found no basis to question the appropriateness of cost estimates for plant construction and major reactor and nonreactor components. These costs represent approximately $3 billion of the total estimate. However, GAO found that DOE's estimates did not include one cost item, and the range of uncertainty associated with other items was significant. In addition, GAO had questions concerning the appropriateness of the inflation rate and the size of the contingency allowance which DOE used in developing the cost estimates.

Revenue estimate

DOE's $3.6-billion estimate includes a $679.7-million offset to account for revenues that TVA will pay DOE for electricity produced during the 5-year demonstration. The revenue calculation is based on the amount of electricity that will be generated by CRBR.

Depending on the assumptions used to project revenues, they could be as much as $212 million lower than DOE's estimate. This is because

--The price that DOE used to calculate revenues is higher than the purchase price that TVA agreed on in its contract with DOE. (See p. 6).

--The amount of electricity that can be sold depends on the availability of CRBR to produce electricity. This is generally expressed in terms of a capacity factor. DOE's estimates are based on a capacity factor of 75 percent as compared to TVA's actual experience of 61 to 65 percent with nuclear powerplants. (See pp. 6 and 7.)

Cost estimates

As discussed below, the uncertainties associated with several items in DOE's cost estimate could have a significant impact on the CRBR project cost.

--One of the most significant costs associated with the operation of CRBR is the plutonium needed to fuel the reactor. DOE includes $10 million in its estimate for plutonium fuel. However, DOE did not consider reprocessing costs. If these costs are considered, the total fuel cost could range from $196 million to $261 million. (See pp. 7 through 10.)

--DOE estimated operating and maintenance costs during the 5-year demonstration period at $318.3 million. This is based on a slightly lower cost escalation rate--inflation rate and real cost growth--than what TVA uses for its own projects. Using the TVA rate would increase operating and maintenance costs about $54.8 million. (See p. 10.)

--Because nuclear powerplants historically have been subject to extensive regulations, legal actions, and design changes, DOE's estimate includes a contingency allowance of $165.6 million, about 8.7 percent of remaining costs. Using the historical real cost growth rate for nuclear powerplants of 12 percent or TVA's contingency allowance of 16 percent results in a range of contingency allowances of $302 million to $644.3 million. (See pp. 11 and 12.)

--DOE does not include the costs of its employees assigned solely to the CRBR project office in its cost estimate. Including these costs would increase the estimate about $29 million to $39 million. (See pp. 13 and 14.)

--DOE uses an inflation rate of 8 percent for the years 1983 through 1994. Recent experience indicates a lower rate may be appropriate. Inflation costs could be $43.7 million less than what DOE has included. (See p. 14.)

Another issue is imputed interest associated with the CRBR. Imputed interest calculations recognize that there is an interest cost associated with Federal debt. Imputed interest is a nonexpenditure item, and neither DOE nor the Office of Management and Budget require it to be included in the cost of Government projects. Nevertheless, it is a real cost which GAO believes is relevant to congressional decisions on funding projects, such as CRBR, which require large capital investments. Imputed interest associated with the CRBR is about $3.9 billion. (See pp. 14 and 15.)

UNCERTAINTIES IN DOE'S $8 BILLION NET REVENUE ESTIMATE

DOE estimates that a net revenue of $8 billion (approximately $16 billion in revenue less approximately $8 billion in operating and maintenance expenses) would be generated through operation of CRBR after the 5-year demonstration period. Such an estimate requires making many assumptions as to what will be happening to both electricity and the nuclear power industry during the period 1995 to 2020. GAO found that the range of uncertainty in DOE's estimate was such that changes to certain assumptions could produce a loss of approximately $2 billion during this same period.

Revenue uncertainty

The same uncertainties affecting revenue during the 5-year demonstration period also pertain during the 25-year period. DOE's

revenue determination of $16 billion essentially is made up of two items--the availability of CRBR to produce electricity and the rate at which that electricity can be sold. GAO found that less optimistic assumptions could reduce the revenue estimate by as much as $3.6 billion. (See pp. 16 and 17.)

Expense uncertainties

DOE's expense calculation of $8 billion is essentially made up of $4.7 billion in operating and maintenance costs and $3.1 billion to manufacture the fuel assemblies. GAO found that less optimistic assumptions could increase DOE's operating and maintenance expense estimate. More importantly, though, DOE excluded from its calculation the cost of plutonium needed to fuel the reactor for the 25-year period. Specifically:

--DOE's operating and maintenance expense of $4.7 billion is based on an escalation rate of 8 percent. TVA, the operator of the powerplant, uses a higher escalation rate for its own nuclear powerplants. Use of TVA's escalation rate would increase operating and maintenance costs about $1.5 billion over DOE's estimate. In addition, use of the TVA rate would permit increased electricity production during the last 10 years of operation, therefore increasing revenues during that period. (See p. 17.)

--Similar to its treatment of plutonium fuel cost during the 5-year demonstration period, DOE excluded the cost of plutonium in its estimate. Based on DOE's defense programs estimate of the costs of reprocessing fuel and allowing a credit for excess fuel produced, fuel costs could be as high as $5.1 billion after the demonstration period. (See p. 18.)

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As requested by the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, GAO did not obtain DOE's official comment on this report. However, GAO has discussed the contents with DOE officials in an effort to include DOE's views and ensure the accuracy of the report.

Contents

ABBREVIATIONS

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

CHAPTER 1

INTRODUCTION

The Congress is currently debating whether to continue funding the Clinch River Breeder Reactor (CRBR) demonstration powerplant. Much of the debate centers around its estimated cost. When the CRBR was originally authorized by the Congress in 1970, the Government estimated that it would cost $699 million 1/ to design, build, and operate the powerplant for a 5-year demonstration period. In September 1982, the Department of Energy (DOE) revised this estimate to $3.6 billion. Further, DOE has recently introduced an additional factor to the debate by maintaining that the CRBR powerplant will, over its remaining life, generate electricity that will produce about $8 billion in net revenue.

On September 23, 1982, we issued an interim report to the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce. 2/ That report discussed potential overstatements and understatements in a number of areas of DOE's cost estimate, including inflation, fuel costs, revenues, contingencies, salaries, and interest expense. This report further elaborates on the range of uncertainties associated with these estimates and discusses the impact of these and other uncertainties on DOE's estimate of the net revenue that the CRBR is expected to produce.

BACKGROUND

Most commercial nuclear power reactors in the United States are light-water reactors. Because reserves of economically recoverable fuel needed for light-water reactors are finite, DOE and its predecessor agencies have been developing an alternative to current nuclear powerplants--the liquid metal fast breeder reactor (LMFBR). 3/ Breeder reactors are designed to

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1/Throughout this report, unless otherwise noted, all dollar amounts are expressed as current year amounts. Current year dollars represent the dollar value of a good or service in terms of prices current at the time the good or service is bought or sold. This is in contrast to the value of the good or service in constant dollars.

2/"Interim Report on GAO's Review of the Total Cost Estimate for the Clinch River Breeder Reactor Project," GAO/EMD-82-131.

3/Liquid metal refers to the liquid sodium used as the coolant to carry off the heat of the nuclear reaction. In a "fast" reactor the chain reaction is sustained primarily by high speed, fast neutrons rather than by slower speed, moderated neutrons as in the present generation of commercial light-water reactor powerplant.

produce more nuclear fuel than they consume while generating electricity and could help extend the Nation's usable uranium reserves.

In 1970, the Congress authorized the Atomic Energy Commission (AEC) 1/ to enter into cooperative arrangements with private industry to build and operate the CRBR project. Because the purpose of the project was to demonstrate that an LMFBR can be designed, built, and licensed in a utility environment, extensive private sector participation was obtained. On July 25, 1973, AEC entered into a contract with the Tennessee Valley Authority (TVA), Commonwealth Edison Company, and the Project Management Corporation 2/ to develop and successfully demonstrate the CRBR by 1980. In addition, TVA was given the responsibility for operating the CRBR during a 5-year demonstration period. AEC originally estimated that $699 million would be required to design, construct, and operate the project for the 5-year demonstration period. Private project participants were expected to provide from $274 million to $294 million, including $20 million to $40 million from reactor manufacturers (private participants' contributions are currently estimated at about $352 million). AEC was authorized to contribute a total of about $422 million--$92 million in direct financial assistance, $10 million in plutonium fuel, and $320 million in development assistance from AEC's ongoing LMFBR base research and development program. The $699-million estimate was prepared before detailed design plans and construction schedules were developed. Following this estimate, a number of environmental, technical, and economic issues surfaced which necessitated a reappraisal of the cost and schedule estimates. In August 1974, the Government and industry participants developed a new estimate of $1.736 billion.

Since 1974, the estimated cost of CRBR has been revised six times. The most recent estimate was contained in September 15, 1982, letters to Senator Gary W. Hart and Representative Richard L. Ottinger. In these letters, DOE indicated that the current estimated cost of the CRBR demonstration project was about $3.6 billion. This estimate is based on starting site preparation in September 1982, 3/ initial criticality 4/ in 1989, and fiscal year 1983 funding of $252.5 million. Under these assumptions, CRBR's 5-year demonstration would begin in 1990.

1/The Atomic Energy Commission was a predecessor agency to DOE.

2/Project Management Corporation is a nonprofit corporation which represents the interest of the utilities in the CRBR project.

3/Site preparation actually began in September 1982 and was still ongoing as of December 1982.

4/Criticality is that state of a nuclear reaction when it is sustaining a chain reaction. This is the point when a nuclear powerplant is considered operational.

In 1995, at the end of the demonstration period, DOE could terminate the CRBR project, sell CRBR to TVA, or continue to operate the plant and sell the electricity generated. Current plans are for CRBR to operate for about 30 years, until about 2020.

Also in the letters to Senator Hart and Representative Ottinger, DOE introduced another issue. DOE stated

> "In addition, the CRBRP will generate sufficient electric energy to meet the residential needs of a city of 200,000 people, and will, over its operating life, generate net revenues in excess of $8 billion." [underscoring added]

As of December 1982, DOE is in the process of preparing the site in Oak Ridge, Tennessee, where construction of the reactor is scheduled to start in 1984. DOE plans to start operation in fiscal year 1989 and complete the 5-year demonstration in 1995. As of September 1982, DOE had spent $1.3 billion on CRBR.

PAST GAO REPORTS ON THE CRBR

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

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

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

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

--"The Liquid Metal Fast Breeder Reactor--Options for Deciding Future Pace and Direction (GAO/EMD-82-79, July 12, 1982).

OBJECTIVE, SCOPE, AND METHODOLOGY

The objective of this review was to respond to an April 28, 1982, request from the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, that we analyze the most current cost estimate for designing, constructing, and operating the CRBR demonstration plant during the 5-year demonstration period. We were specifically requested to consider such factors as inflation rates, anticipated revenues, allowance for contingencies, and cost of plutonium.

In performing our work, we discussed the estimating process used with DOE project officials and contractor officials and selectively reviewed summary data submitted by the prime and major subcontractors. The purpose of this audit work was to verify the accuracy of the summary data.

Because TVA is responsible for operating the CRBR, our audit work included evaluating DOE estimates of revenues and operating expenses to actual TVA experience with nuclear powerplant construction and operation.

We compared the inflation rate used by DOE for the cost estimate with current and projected inflation rates. We also tested the sensitivity of the total cost estimate to changes in the inflation rate. Our analysis of revenue estimates during the 5-year demonstration period involved reviewing and analyzing revenue projections and underlying assumptions and discussing those projections and assumptions with project, TVA, and industry officials.

For information concerning the cost of the plutonium fuel, we relied on the work done during two other GAO reviews. 1/ That work was supplemented with data gathered during discussions with DOE officials.

Our evaluation of estimated CRBR expenses for contingencies, salaries, imputed interest, and other related items was based on interviewing DOE officials, reviewing related documents, and comparing CRBR's handling of these items with procedures used by other Government agencies and private utilities.

The Subcommittee staff also requested that we review the accuracy of DOE's estimate that CRBR will produce net revenues in excess of $8 billion during its operating life. Detailed support for the revenues and expenses contained in this estimate were no longer available from DOE. We evaluated the estimate using forecasts and projections obtained from TVA, DOE's defense programs, industry sources, and discussions with personnel instrumental in developing DOE's estimate.

This review was conducted in accordance with generally accepted government audit standards. As requested by the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, we did not solicit DOE's review and comments on a draft of this report. However, we have discussed the contents with DOE officials in an effort to include DOE's views and ensure that the report is as accurate as possible.

1/"DOE Confident It Can Fuel the Clinch River Breeder Reactor and Other Breeder Reactor Projects," GAO/EMD-82-89, May 14, 1982; and "Information on the Cost of Plutonium Needed to Operate the Clinch River Breeder Reactor for Its 5-Year Demonstration," GAO/EMD-82-128, September 17, 1982.

CHAPTER 2

UNCERTAINTIES AFFECTING THE CRBR COST ESTIMATES

DOE estimates that it will cost $3.6 billion to design, construct, and operate CRBR during its 5-year demonstration. This estimate reflects the cost less the revenue that DOE believes will accrue from the sale of electricity generated by the CRBR during the demonstration period. We found no basis to question the current cost estimates for plant construction and major reactor and nonreactor components. These components account for over $3 billion of DOE's estimate.

However, we found that DOE's estimate did not include one cost item, and the range of uncertainty associated with other items in DOE's estimates was significant. In addition, we had questions concerning the appropriateness of the inflation rate DOE used in calculating the project's cost and the amount of the contingency allowance included in the cost estimate. This chapter describes the appropriateness, basis, and uncertainty associated with the DOE revenue estimate and cost estimates for fuel, operating and maintenance, salaries of Federal employees assigned to the CRBR project, contingency allowance, and inflation rate.

In addition, we discuss the impact of imputed interest on the CRBR cost estimate. Imputed interest is the interest that the U.S. Treasury pays on money borrowed to fund Federal programs and projects. Imputed interest is a nonexpenditure item and neither DOE nor the Office of Management and Budget procedures require it to be included in the cost estimates of Government projects. Nevertheless, it is a real cost which we believe is relevant to congressional decisions on funding projects, such as CRBR, which require large capital investments.

REVENUE ESTIMATE

DOE's $3.6-billion estimate includes a $679.7-million offset to account for the sale of electricity produced by CRBR during the 5-year demonstration period. We found that the revenues could be as much as $212 million less than DOE estimated for two reasons:

--TVA's contract with DOE provides for purchase of electricity at TVA's incremental cost of production. DOE, however, assumed a higher rate. TVA has advised DOE that it anticipates purchasing electricity at the lower rate.

--Although rated at 350 megawatts, CRBR's output will average less than that level due to refueling and maintenance downtime. Further, while CRBR officials think that a 75-percent

capacity factor 1/ is achievable during the demonstration period, the nuclear industry average capacity factor for the last 3 years is under 65 percent, and the French Phenix experimental breeder reactor (roughly comparable in size to CRBR) averaged less than 60 percent during its first 5 years of commercial operation.

Rate uncertainties

In the 1973 cooperative agreement, TVA contracted to buy the power produced by the CRBR. According to that contract, TVA will pay DOE at a rate equivalent to the cost of the electricity that the CRBR plant replaces (i.e., the incremental cost for TVA to produce that power at TVA facilities or buy it from other utilities). TVA currently is capable of generating more electricity than needed. If that situation continues, the purchase price, according to the contract, should be the cost of TVA production.

TVA has computer models which can simulate the operation of its system and forecast costs several years into the future. In August 1981, at the request of CRBR officials, TVA used its models to supply CRBR officials with estimates of incremental costs for power during the 5-year demonstration period. CRBR officials, however, did not use these estimates but instead calculated the expected revenues based on the amount TVA pays for electricity from cogenerators. 2/

CRBR's use of cogeneration rates resulted in a revenue estimate that is about $53 million higher than estimated revenues based on TVA's incremental rates.

Capacity uncertainties

CRBR officials assumed that the plant will begin operations at about a 20-percent capacity factor. After 37 months of operation, they assume the plant will operate at a 75-percent capacity factor. However, the assumption that the CRBR plant will achieve a 75-percent capacity factor that early in its operating life may be unrealistic. Light-water reactor powerplants have experienced capacity factors that are considerably

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1/Capacity factor is the ratio of the average power load of an electric powerplant in comparison to its maximum capacity, expressed as a percent.

2/Cogenerators are private electricity producers which sell excess power to TVA. TVA purchases electricity from cogenerators at a rate which is based on TVA's wholesale sales price. TVA's wholesale sales price is higher than TVA's incremental cost of production. Therefore, the rate used by DOE (the cogeneration rate) is higher than the rate specified in the contract--the incremental cost of production.

less than 75 percent. According to data compiled by TVA from Nuclear Regulatory Commission (NRC) reports, the nuclear industry had an average capacity factor of 62 percent in 1979, 60 percent in 1980, and 61 percent in 1981. 1/ TVA, similarly projects a 65-percent capacity factor for its boiling-water nuclear reactors and 61 percent for its pressurized water nuclear reactors.

The actual operating experience of the French Phenix, a CRBR-size breeder demonstration plant, further indicates that use of a 75-percent capacity factor assumption may be overly optimistic. An August 1981 report by the Electric Power Research Institute showed that the Phenix plant had an average capacity factor of 58 percent from the time it began commercial operation in July 1974 through 1980. During the third, fourth, and fifth years of its operation (comparable to the last 3 years of CRBR's 5-year demonstration period), the Phenix had capacity factors of 16, 61, and 84 percent. During 1980 and 1981, it experienced capacity factors of 65 and 71 percent, respectively.

Using a 63-percent capacity factor during the last half of the demonstration period (i.e., halfway between the 61 and 65 percent figures that TVA uses) and using the TVA-supplied incremental costs, the revenue expected during the CRBR 5-year demonstration would be about $120 million lower than the revenue estimated in the current CRBR cost estimate.

Since DOE prepared its estimate, TVA has updated its estimate of incremental costs. This update showed that the incremental cost estimates are even lower than forecasted in August 1981. Using TVA's latest estimate (October 1982) as the price for CRBR-generated electricity and our assumption of capacity factors, the revenues during the CRBR demonstration period would be $467.6 million rather than the $679.7 million included in the CRBR cost estimate--31 percent lower. The effect, since revenues are an offset to cost, would be to increase the cost estimate by about $212 million.

PLUTONIUM FUEL COST

One of the most significant and uncertain costs directly related to operating the CRBR is the plutonium needed to fuel the reactor during the demonstration period. DOE currently includes $10 million in its cost estimate for plutonium. This estimate is based on purchasing the plutonium for the first core and, because the fuel assemblies are expected to contain more plutonium when removed than when loaded, exchanging the plutonium in the spent assemblies for the plutonium in the new fuel assemblies.

1/TVA excluded the Three Mile Island-Unit II, Dresden-Unit I, and Humbolt Bay plant because they may never return to service.

This estimate fails to recognize the cost of reprocessing to recover the plutonium from the spent fuel assemblies. When reprocessing costs are considered, the plutonium fuel costs could range from $196 million to $261 million.

Cost and source of plutonium uncertain

DOE's Office of Nuclear Material Production, which is under the Assistant Secretary for Defense Programs, is responsible for meeting the Government's plutonium requirements. Defense program officials are unable at this time to identify the specific source or cost of plutonium needed to fuel the CRBR's demonstration operations. Instead, these officials believe that, based on the current CRBR schedule with initial criticality in September 1989, a decision on the source of plutonium for the CRBR will not be required until 1986. At that time, they expect to have definitive plutonium cost estimates.

DOE's defense programs officials said that the plutonium needed for the CRBR can be provided from a number of different sources, including defense programs activities, reprocessed light-water reactor spent fuel, and/or foreign sources. According to these officials, the costs associated with each of these sources not only vary widely, but also in some cases, are highly speculative.

Currently, the only domestic source of plutonium is from DOE's defense programs activities--either existing plutonium inventories, future production, or a combination of both. Depending on whether the plutonium is taken from existing inventories or from production, the value of the plutonium needed for the 5-year CRBR demonstration could range from $143 million to $1.2 billion.

Defense program officials point out, however, that they expect the quantity of plutonium supplied the CRBR will eventually be returned to the defense program. In their view, the only cost to the Government and CRBR would be the cost associated with reprocessing the spent fuel assemblies as the necessary step in recovering the plutonium. Based on defense programs officials' estimates, such reprocessing would cost from $196 million to $261 million for the 5-year demonstration period.

This approach does not recognize that a provision in the NRC Authorization Bill for fiscal year 1982 and 1983 (H.R. 2330), now under consideration by the House/Senate Joint Conference Committee, might have a substantial impact on the planned transfer of plutonium produced by the CRBR to defense program uses. This bill would prohibit the use of plutonium from NRC-licensed facilities in the manufacture of nuclear explosives. CRBR will be an NRC-licensed facility. Defense program officials feel, however, that

this provision will have little impact on the return of defense-supplied plutonium. They believe that if the fuel supplied to CRBR was produced at a defense facility, the fuel returned from CRBR still should be considered as plutonium produced at a defense facility. We have not, as part of this review, analyzed the legality of DOE's position concerning the return of CRBR plutonium for defense purposes.

According to defense program officials, the plutonium for CRBR could also be obtained from reprocessed light-water reactor spent fuel assemblies. These officials estimate that plutonium obtained this way could range in cost from $15 per gram to $35 per gram. That cost range, however, is extremely speculative. It is based on DOE's preliminary estimates of prices they think could be negotiated for domestic reprocessing services.

In this regard, a commercial capability to reprocess light-water reactor spent fuel does not now exist in this country. Although several reprocessing facilities are being considered, no decision has been made, and it is unclear whether those facilities could be available to meet the CRBR project schedule and plutonium requirements. DOE's existing defense program reprocessing facilities cannot recover plutonium from breeder fuel assemblies because of physical and chemical process limitations. DOE has requested $5.6 million for conceptual design efforts to modify one of its reprocessing facilities to enable it to reprocess spent fuel from light water reactors, the Fast Flux Test Facility 1/ and the CRBR. DOE's preliminary estimates indicate the modification could be operational by fiscal year 1989 if the project is authorized by the Congress.

Another option under consideration includes a demonstration size fuel reprocessing facility. DOE's Consolidated Fuel Reprocessing Program is a comprehensive, centrally managed program for all U.S. fuel reprocessing research and development. According to DOE's Director of Nuclear Research and Development, Oak Ridge Operations Office, since 1976, the focal project for reprocessing research and development has been DOE's "Hot Experimental Facility." In June 1981, a conceptual design study for the Hot Experimental Facility was completed. This facility, however, does not have congressional authorization nor has it received construction funding. The Director estimates it would require about 10 years from start of construction to achieve normal operations.

1/The Fast Flux Test Facility is the LMFBR test reactor built for testing fuels, materials, and components. It has no capability of generating electricity nor is it intended to demonstrate the breeding of plutonium fuel.

Finally, defense program officials state that needed plutonium could be acquired from foreign sources. They add, however, that this would involve high-level policy decisions and sensitive, direct country-to-country negotiations. DOE officials told us that no negotiations are underway to acquire plutonium for CRBR from foreign sources nor are any related cost estimates currently available.

OPERATING AND MAINTENANCE EXPENSE

DOE estimates that CRBR will incur about $318.3 million in operating and maintenance expenses through the end of the 5-year demonstration period. The operating and maintenance expense may be understated because of the use of an escalation rate which may be too low. DOE, consistent with its assumption for other CRBR costs, assumed an 8-percent escalation rate for the operating and maintenance expenses. In comparison, TVA, the organization that will staff and operate the CRBR powerplant, uses a slightly higher escalation rate.

TVA estimates a composite escalation rate for the labor and materials that make up the operation and maintenance costs. To this rate, it adds 2 percent, beginning the second year of the plant's operation and continuing throughout its life. TVA Power Planning Staff personnel said this is based on TVA's actual experience with powerplants. TVA adds the 2 percent because its experience indicates that as a plant gets older, it needs an increasing amount of maintenance to keep it operational. The TVA Power Planning Staff believes that by spending the higher amounts, it can maintain a high capacity factor in the later years of a plant's life. Applying the TVA escalation rate to the CRBR estimate of operating and maintenance expenses increases these expenses by about $54.8 million.

There is another area of uncertainty concerning the creation of the operating and maintenance estimate. To determine the amount of the operating and maintenance expenses, the Assistant Director for Operations completed a detailed analysis considering significant operating and maintenance factors such as expected staffing levels, personnel costs, actual expenditures and budgets for operating, and maintenance supplies. The summation of all expenses thought to be appropriate was submitted as the estimate of operating and maintenance expense. However, the CRBR Project Manager made a decision to reduce the estimated amounts by 10 percent. The Project Manager believed the original estimate was too high due to an overreaction to the Three Mile Island incident. However, he applied his reduction "across-the-board" and did not attempt to allocate the reduction to specific elements of the estimate.

While we have no basis to judge which of the two estimates is more reasonable, the variation between the two identifies another source of uncertainty in CRBR cost estimate.

ALLOWANCE FOR CONTINGENCIES

DOE included an allowance of $165.6 million for contingencies in its cost estimate ($165.6 million is about 8.7 percent of remaining costs). A contingency allowance recognizes that nuclear powerplants may incur unanticipated costs for such things as design changes and construction delays. Based on TVA and utility companies' experience, the contingency estimate appears low, and thus, may understate CRBR cost. Applying the rates actually experienced by TVA and others in constructing commercial nuclear powerplants to the estimated cost to complete CRBR produces a range of estimates for contingency of $302.9 million to $644.3 million.

While estimating contingencies is a speculative exercise, we used two methods based on utilities' light-water reactor experience to estimate contingencies for their powerplants. The first method uses actual experience with specific nuclear powerplants to determine the contingency amounts for CRBR. The second method makes use of the real cost growth for nuclear powerplants during recent years to forecast CRBR cost growth.

TVA experience with contingency allowances

TVA calculates the contingency allowance for its nuclear powerplants by estimating an allowance for known scope changes plus an allowance for future scope changes. The contingency percentages on three of TVA's nuclear powerplants which it is currently constructing range from 16 to 22 percent of remaining costs. 1/ Applying these rates to CRBR's remaining estimated costs of about $1.9 billion results in a range of contingencies from about $303 million to $417 million. DOE currently allows $165.6 million for contingencies. Thus, the CRBR contingency allowance may be understated by approximately $137 million to $251 million.

Cost growth for nuclear powerplants

Using the historical cost increases in the nuclear industry also indicates the potential need for a higher contingency allowance. TVA's General Manager recently stated that nuclear plant construction costs actually escalated over the last decade at a rate of 17 to 22 percent annually while general inflation was less than 10 percent overall.

Based on historical nuclear costs escalation, we calculate that a contingency allowance ranging from about $375.9 million to

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1/The range of contingency percents exists because the three powerplants are at various stages of completion. As a powerplant nears completion, the size of the contingency for unknowns diminishes.

$644.3 million would be needed if CRBR costs were to increase 7 to 12 percent per year faster than the inflation rate. Since CRBR's cost estimate has a contingency of $165.6 million, these calculations indicate that the contingency allowance may be understated by from about $310.3 million to $478.7 million.

Arguments for and against a higher contingency allowance

DOE believes that cost increases in the CRBR program will not be as great as that which has been experienced by light-water reactors. DOE bases its position on the fact that:

--More effort has been expended in designing the CRBR than on any light-water reactor plant.

--The CRBR is supposed to be completely designed prior to the start of construction, whereas light-water reactor plants are usually less than one-half designed when construction is started.

--A model of the plant is being constructed as design progresses. This (1) should minimize instances in which it is found at the construction site that two areas of the design conflict and work must stop until the problem can be resolved and (2) should help construction supervisors at the site to "visualize" the work.

--The plant will be built under the Nuclear Power Stabilization Act which prohibits strikes and gives the construction manager more flexibility in assigning workers, which should improve efficiency.

Conversely, other factors support a position that the CRBR may experience greater cost increases than the light-water reactor industry has experienced, such as the following:

--The CRBR is a first-of-a-kind demonstration facility using many first-of-a-kind components.

--The breeder uses a less proven technology than the light-water reactor industry. There are no commercial electricity generating breeders in this country, while there are 72 commercial light-water reactor plants currently in operation.

--The breeder may be subject to more stringent NRC requirements because (1) it has a less proven technological base and (2) there are additional safety-related questions with the breeder (it uses plutonium for fuel, and, since it uses liquid sodium for cooling, there is a possibility of a sodium-water reaction, the consequences of which could be serious).

SALARIES OF FEDERAL EMPLOYEES IN THE CRBR PROJECT OFFICE

The personnel costs of DOE employees assigned to the CRBR project office are not included in the cost estimate. These costs could range from about $29 million to $39 million through the end of the demonstration period. DOE believes that the costs of DOE employees assigned to the CRBR project office are more appropriately identified with the overall LMFBR program of which CRBR is a part.

Since 1975, DOE and the Project Management Corporation have assigned employees to full-time positions in the CRBR project office in Oak Ridge, Tennessee. The personnel costs of the Project Management Corporation employees have been included in the project's estimated cost, whereas the personnel costs of DOE employees assigned full time to the CRBR project office have not been included. Instead, these costs are charged to the LMFBR program office in Germantown, Maryland.

In 1981, an average of 25 DOE full-time employees were assigned to the CRBR project. From 1976 through 1981, the salary costs for DOE employees totaled $8.7 million. DOE has not projected such costs through project completion. Making a conservative assumption that such salaries will be spent at the same rate through project completion, the total cost for these DOE employees could range from about $29 million to $39 million through 1994.

The Acting Director, Budget Analysis Division, DOE's Office of Budget, told us that personnel costs are allocated based on the mission of the project. For example, the CRBR project is just one part of the larger LMFBR program. The technology and experience gleaned from the development of the CRBR project benefits the LMFBR program as a whole. DOE, therefore, believes that it is appropriate to charge personnel costs to the LMFBR program. The same DOE official stated that he agreed that in order to accurately reflect the total cost of the CRBR project, the estimate would have to include DOE personnel costs. However, he reemphasized that the personnel costs are not significantly large enough to distort the costs of the CRBR project.

In contrast to DOE's current position, however, a 1977 letter from the CRBR Project Director to the Energy Research and Development Administration's (ERDA's) 1/ Controller stated ERDA administrative costs, including personnel, should be included in the project's cost and the Project Director was ready to implement the change if so directed. The Director, Division of Reactor Research and Development, in another 1977 letter to the Controller also agreed, stating "The efforts of the CRBRP Project Office personnel are devoted exclusively to managing the CRBRP Project." No action was taken to include federal personnel costs in the project's cost.

1/ERDA was a predecessor agency to DOE.

INFLATION ESTIMATES

The CRBR cost estimate includes an annual allowance for inflation of 8 percent. In recent months, however, inflation has been at a rate which would be less than 8 percent. Estimating the rate of inflation in the future is speculative. However, if recent trends continue, the CRBR total cost estimate may be overstated.

Data Resources, Inc., a nationally recognized forecaster, recently forecasted inflation rates that will average 6.25 percent between 1983 and 1994. DOE included a $231.7-million allowance for 8 percent inflation in its cost estimate. Using Data Resources, Inc.'s inflation rate, the inflation allowance would be $188.0 million, or $43.7 million less.

IMPUTED INTEREST FOR THE CRBR

The imputed interest associated with the CRBR cost estimate is about $3.9 billion. DOE officials maintain that neither DOE nor Office of Management and Budget procedures require imputed interest to be included in cost estimates for DOE projects. Nevertheless, it is a real cost to the Government and, in our view, is relevant to congressional decisions on funding projects such as the CRBR, which require large capital investments.

Disbursements for the CRBR, as are nearly all Government disbursements, are made from a single pool of funds managed by the Treasury Department. In managing the Government's funding requirements, the Treasury Department does not earmark funds either by source or by use; instead, it is concerned with the total it must have available to meet all demands. When total receipts are insufficient to meet total demands, the Treasury obtains the difference through borrowing. The cost of interest from such borrowing can be attributed to an individual agency or project even though the agency will not actually incur the cost.

Cumulative net expenditures of Federal funds for the CRBR project will be about $1.2 billion through fiscal year 1982 and will approach $3.0 billion by the end of the demonstration period. Using the average yearly interest rate for 12-month Treasury bills, the cumulative imputed interest through fiscal year 1982 will exceed $400 million. Based on projections of future interest rates, published by Data Resources Inc., cumulative imputed interest on the CRBR project through 1994 (the end of the project's 5-year demonstration period) would exceed $3.9 billion.

In contrast to the above position, DOE has, in certain situations, recognized imputed interest. For example, when DOE requested NRC authorization to begin early site clearance activities, it

included imputed interest as a cost of construction which would increase if the project is further delayed. In a January 18, 1982, 1/ letter to NRC, DOE stated that the yearly interest costs of delaying CRBR amounts to approximately $110 million per year. DOE also includes imputed interest as part of recoverable costs in other revenue-producing activities and projects such as uranium enrichment.

In addition, NRC regulations (10 CFR pt. 50, app. C) require applicants for construction permits and operating licenses to submit estimates of construction costs. The regulations provide that the items included in the cost estimate should be the same as those defined in the applicable electric plant and nuclear fuel inventory accounts (18 CFR pt. 101) prescribed by the Federal Energy Regulatory Commission. The Federal Energy Regulatory Commission's regulations define "allowance for funds used during construction" to include the net cost of borrowed funds and a reasonable rate on funds that are not borrowed.

1/On November 30, 1981, DOE requested an NRC exemption which would allow the start of site preparation before completion of the NRC license review.

CHAPTER 3

CRBR'S NET REVENUES UNCERTAIN

At the end of the 5-year demonstration period (about 1995), DOE will have three options concerning the future of CRBR. DOE could sell CRBR to TVA if TVA is willing to buy it, keep the powerplant and continue to receive revenues for the electricity it generates, or terminate the project. Because termination is always an option at any time on all research and demonstration projects, DOE is only considering the first two options. DOE stated in its September 15, 1982, letters to Senator Hart and Representative Ottinger that "* * * CRBR will over its operating life generate net revenues in excess of $8 billion * * *." An analysis of DOE's support reveals that DOE estimates that CRBR will generate over $8.5 billion in net revenues over its lifetime, with $8.2 billion being generated in the 25-year post-demonstration period. If DOE sells the facility to TVA, the selling price, according to the terms of DOE's contract with TVA, will be based on the discounted value of the net revenues. Using DOE's $8.2-billion net revenues estimate, the selling price would be about $1.4 billion.

Many of the uncertainties in predicting future revenues and expenses, which are discussed in chapter 2 also affect the cost and revenues during the 25-year post-demonstration period operation. The difficulty centers around attempting to make projections about the future on the basis of assumptions that are uncertain. Based on best case/worst case scenarios, net revenue projections over the 25-year post demonstration period could range from $8 billion to a negative $2.0 billion. Long range projections are inherently uncertain and, in the case of the CRBR, which is basically a research and development project, do not appear appropriate.

WIDE VARIATION IN REVENUE AND EXPENSE ESTIMATES

The plant capacity and price uncertainties inherent in calculating net revenues during the 25-year post-demonstration period closely mirror the uncertainties involved in estimating CRBR costs during the 5-year demonstration period. If the CRBR is not sold after the demonstration period, DOE calculates that the $8.2-billion net revenues it would receive would more than offset the estimated costs to design, construct, and operate CRBR during the 5-year demonstration period. A description of the uncertainties involved in projecting revenues and expenses follows.

Revenues

The factors used to calculate post-demonstration revenues are very similar to those used in calculating revenues during

the demonstration period. DOE continues to assume prices based on TVA's cogeneration rate. These rates are higher than the rate which TVA expects to pay for CRBR electricity (see p. 6). For capacity factors beyond the demonstration period, DOE assumes a 75-percent capacity factor through 1999 and an 80-percent factor from 2000 through 2010. From 2010 through 2020 (the end of the estimated 30-year life), DOE assumes a gradually declining capacity factor, ending with a 45-percent factor in 2020. Based on these assumptions, DOE estimated generation of about 61.8-million megawatt hours of electricity and associated revenues of about $16 billion.

Using the incremental price projections provided by TVA and assuming the 63-percent capacity factor--an average of the factors used by TVA in projecting nuclear powerplant capacity (see p. 6)--throughout the post-demonstration period results in about 54.3 megawatt hours of electricity production. Gross revenues on the sale of that electricity would be about $12.4 billion, or about $3.6 billion less than DOE's projected revenues.

Operating and maintenance expenses

DOE estimates that operating and maintenance expenses will total about $4.7 billion during the post-demonstration period. However, as discussed on page 10, operating and maintenance expenses could escalate at a higher rate than estimated by DOE. Applying the TVA escalation rate to DOE's estimate of operating and maintenance expense indicates that the expense could be as much as about $1.5-billion higher than estimated by DOE. According to TVA Power Planning Staff, using the higher escalation rate would allow for better plant maintenance, which in turn would allow maintaining a constant capacity over the last 10 years of operation.

Fuel fabrication

Because of time constraints, we did not review, in detail, the data supporting DOE's fuel fabrication cost estimates of $3.1 billion for the post-demonstration period. We note, however, that beginning in 2007, DOE assumes the CRBR powerplant will operate approximately 3 years between refueling. The Acting Technical Director for the CRBR Plant, in DOE's Office of Demonstration Projects, explained that this assumption is consistent with DOE's reduction of the capacity factor beginning in 2011. This assumption, however, is at variance with DOE's CRBR fuel cycle planning documents and with DOE statements concerning the quantity of plutonium produced by the CRBR powerplant over its 30-year operating life. Furthermore, if annual megawatt-hours of electricity generation are taken as the measure of fuel use, the plant's capacity factor will need to drop below 53 percent before the CRBR could operate for 3 years between refueling. DOE plans indicate this will not occur until 2018.

Net fuel costs

Similar to its treatment of fuel costs during the 5-year demonstration period, DOE excludes the cost of plutonium needed to fuel the CRBR powerplant from its 30-year forecast of CRBR revenues and operating costs. Based on defense programs' estimates of the cost of reprocessing, fuel for CRBR could cost as much as about $5.1 billion for the post-demonstration period. 1/ This includes a credit for the value of the excess plutonium which is produced.

We discussed our use of defense programs' estimate with CRBR's Assistant Director for Engineering. He stated that using reprocessing cost estimates for a demonstration reprocessing facility or from a facility similar to the nonoperating reprocessing plant at Barnwell, South Carolina, would result in considerably lower fuel estimates. The Assistant Director for Engineering cited a document prepared for the Division of LMFBR Fuel Cycle Projects in DOE's Office of Spent Fuel Management and Reprocessing Systems as support. Our review of that document indicated that it did not provide support for using lower estimates. Furthermore, the Director, Division of LMFBR Fuel Cycle Projects agreed with our assessment.

We continue to believe use of estimated costs obtained from DOE's defense programs officials is reasonable because defense programs has actual experience with reprocessing fuel. Because DOE does not include any fuel costs in its net revenue calculations, our $5.1-billion estimate reduces DOE's net revenue figure by that same amount.

RESIDUAL VALUE OF CRBR IS UNCERTAIN

DOE's other option--the alternative to DOE's continued operation of CRBR beyond the demonstration period--is to sell the facility to TVA, if TVA is willing to buy it. The contract calls for sale price to be the residual value of the CRBR at the end of the 5-year demonstration period. The residual value is the discounted value of the net revenues CRBR is projected to produce over its remaining 25-year life. DOE estimates that during post-demonstration operations, CRBR will generate about $16 billion in revenues and incur about $7.8 billion in expenses, resulting in about $8.2 billion in net revenues. When discounted, the residual value of the $8 billion would be about $1.4 billion in 1995, the end of the demonstration period.

1/The defense program officials estimated $15 per gram to $20 per gram for reprocessing. We used the lower value. Use of the higher value would increase the net fuel costs about $600 million.

However, as discussed in this chapter, there is considerable uncertainty in certain of the bases used by DOE to arrive at the $8-billion net revenue. Using less optimistic, but equally plausable assumptions, produces a drastically different estimate of the CRBR residual value. For example, gross revenues could be as low as about $12.4 billion and corresponding expenses could be as high as about $14.4 billion ($6.2 billion operating and maintenance expenses, $3.1 billion in fuel fabrication costs, and $5.1 billion for fuel costs). This produces a net loss of about $2.0 billion. Discounting 1/ the net loss produces a negative residual value of about $513 million in 1995.

OBSERVATION

In 1970, the Congress authorized the CRBR project as a research and development project. The purpose of the project was to demonstrate that an LMFBR powerplant could be designed, built, and licensed in a utility environment. Because DOE's long-range estimate of CRBR's revenue and costs are subject to wide variation with changes to underlying assumption and because these estimates are projected so far in the future, we believe that such estimates and projections should not be the dominant considerations in funding decisions for a research and development project, such as the CRBR.

1/We used the discount rate TVA used in its recent decision to cancel the Yellow Creek unit 1 nuclear powerplant. Use of the TVA discount rate is consistent with the provision of the 1973 cooperative agreement.

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