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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

ENERGY AND MINERALS DIVISION

MAY 4, 1981

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The Honorable Claudine Schneider
The Honorable George E. Brown, Jr.
The Honorable Vin Weber
The Honorable Howard Wolpe
House of Representatives

Subject: Response to questions clarifying a previous GAO report on the Department of Energy's breeder reactor program (EMD-81-83)

Enclosed are answers to the seven questions contained in your April 23, 1981, letter asking us for clarification of certain information contained in our report entitled, "U.S. Fast Breeder Reactor Program Needs Direction," EMD-80-81, dated September 22, 1980.

Refer to

In reading the responses to your questions it is important to realize, however, that the September 1980 report was prepared at a time of intense debate among Congress and Executive Branch officials as to what was the best way to proceed with the breeder reactor program, in general, and whether to build the Clinch River plant, in particular. After weighing the evidence on both sides of the debate, we concluded that if the Nation wanted to maintain a strong breeder reactor program the time had come to build a plant and demonstrate the viability of the technology. If not, we thought Congress should consider terminating the program. In essence, from a program development and management point of view, we concluded it was time to either develop a serious program effort or move to phase out the program. Consequently, our earlier report and our answers to the questions you have on it should be placed in that context.

In providing the answers to your specific questions, we wish to emphasize that because of the extremely short period of time allowed in responding to the questions, we relied heavily on data provided by the Department of Energy which we did not independently verify. However, in addition, we used (1) data collected in support of our September 1980 report and other work we have done involving the Clinch River Breeder Reactor, (2) information obtained in interviews with industry officials, and

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(3) information obtained from publications of various trade associations and interest groups.

A list of your questions and our responses is included as Enclosure I to this letter. Further, for your convenience, we have also included a copy of our September 1980 report as Enclosure II and copies of two 1979 reports we prepared on various issues surrounding the Clinch River Breeder Reactor Project as Enclosures III and IV.

If you have any questions or if we can be of any further assistance, please let us know.

J. Dexter Peach
Director

Enclosures - 4

ANSWERS TO QUESTIONS ON GAO REPORT ENTITLED

"U.S. FAST BREEDER REACTOR PROGRAM NEEDS DIRECTION,"

EMD-80-81, SEPTEMBER 22, 1980

Following is a listing of the specific questions you wanted answered on various aspects of our report on the Department of Energy's (DOE) breeder reactor program.

QUESTION 1:

What is GAO's best available estimate of the cost of construction of the Clinch River LMFBR (liquid metal fast breeder reactor) after adjusting for inflation and cost overruns?

ANSWER 1:

According to information we obtained from DOE the total estimated cost for the Clinch River plant is now about $3196.5 million. The following table provides a cost breakdown based on a schedule leading to plant criticality in February 1990, for all engineering, construction and support activities and 5 years of demonstration operation.

Millions of Expenditure Year Dollars

	Total Costs	Private Sector Contributions	Budget Outlays	Budget Authority
THRU:				
FY 1980	$ 955.3	$110.7	$ 844.6	$ 947.3
FY 1981	194.6	7.9	186.7	172.0
FY 1982 & later	2046.6	244.1	1802.5	1714.5
TOTAL	$3196.5	$362.7	$2833.8	$2833.8

The figures in the table include an allowance for contingencies to cover uncertainties in the scope of the project and an assumed 8 percent annual inflation rate.

Question 2:

The GAO report indicates that it does not necessarily advocate building the Clinch River demonstration reactor as part of the U.S. breeder program. (See pp. vi and 46.) What alternative strategies are open to the Congress if it wants to maintain a breeder program?

Answer 2:

There are alternative strategies available to the Congress in developing breeder reactor technology. However, the relative desirability of any given option must be weighed against several important factors like the degree to which the Congress is willing to rely on foreign breeder technology, or the degree to which the United States wants to maintain a comprehensive supporting technology effort of its own.) In this regard, our report was predicated on the explicit commitment of the former administration to maintain a strong national breeder reactor program. Accordingly, our conclusions and recommendations laid out what we believed to be the most efficient, most productive technology development path available to this Nation given the desire to maintain a strong national breeder program. That path is to construct and operate a breeder reactor facility so that progress can be made toward demonstrating breeder technology. However, in recognizing the political realities and controversy that has surrounded the breeder reactor program in general, and the Clinch River Breeder Reactor in particular, and assuming a desire to maintain a long-term nuclear power option, our recommendation to the Congress emphasized the need to build a breeder plant--be it Clinch River or another, more recently designed facility--in order to resolve the impasse that has delayed the progress of technological development for the past 4 years. On the other hand, we concluded that if such a decision was not forthcoming, consideration should be given to terminating the program.

Nonetheless, other than the "marching in place" approach that has been followed for the past 4 years, there does appear to be other available breeder reactor development strategies. Some possible options are to:

1. Construct and operate the Clinch River plant and then scale-up to one or more larger plants prior to commercialization. The multiple plant construction involved would make this a high cost option.

2. Skip the gradual scale-up from earlier U.S. breeder plants that Clinch River represents and move directly to a larger, closer to commercial size

facility(s) prior to commercialization. As some of our past work in this area indicates, this option entails a degree of scale-up risk that could affect the ultimate attractiveness of the plant(s). 1/

3. Abandon the Department of Energy's existing breeder reactor research and development effort and rely on private industry and the utility industry to obtain foreign breeder reactors if and when they are needed commercially.

4. Cut-back on the scope of the Department of Energy's current program which emphasizes domestic construction and operation of breeder reactor plants and attempt to obtain needed plant construction and operating experience via cooperative arrangements among the United States and some foreign partner(s)--e.g., the United Kingdom or Japan--to jointly build and operate breeder reactor plants prior to commercialization

QUESTION 3:

The GAO report refers to the threat of a possible shutoff of Persian Gulf oil as an argument in favor of going forward with Clinch River LMFBR. Assuming Congress decides to fund Clinch River this year, and construction begins and continues on schedule, what effect can the project be expected to have on oil displacement in the following years: 1990, 2000, 2010, and 2020. Please specify the electricity demand assumptions used in your estimates?

ANSWER 3:

Pages ii and 18 of our report state that a cutoff of Persian Gulf oil could increase the future demand for nuclear power. However, as page 18 of the report states, the loss of Persian Gulf oil supply is only one of three possible events that could increase future nuclear growth rates. The other two are (1) the effects of future constraints on the domestic coal supply and (2) limits to new hydroelectric and geothermal generating sites.

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

The main thrust of this issue as discussed in our report is highlighting the uncertainty surrounding the future growth of nuclear power. On one hand, DOE and previous administration officials have cited declining nuclear power projections as part of their justification for delaying the development and demonstration of breeder reactor technology. On the other hand, the occurrence of certain unpredictable, but in our opinion, plausible events like the three we identified above could tend to increase the desirability and the need to build more nuclear powerplants.

We recognize that this argument alone does not make a compelling case on the need to develop breeder reactors sooner rather than later. But, in our judgment, our analyses on pages 10 through 22 of the report demonstrated that the former administration's decision to delay breeder reactor development in the United States was not the most prudent course of action.

Now, to answer your question regarding the effect the Clinch River project can be expected to have on oil displacement in the years 1990, 2000, 2010 and 2020. According to DOE figures, if the Clinch River Breeder Reactor's entire output--about 375 Megawatts electric--was used to displace oil, it would replace more than 1 million barrels of oil per year beginning about 1990. Further, as a rule of thumb, each 1000 Megawatt electric breeder reactor would potentially displace 2.8 million barrels of oil per year. Thus, for an assumed breeder penetration scenario of 1375 Megawatts electric--the Clinch River Plant plus one other 1000 megawatt facility--in the year 2000, 5000 Megawatts electric in 2010, and 10,000 Megawatts electric in 2020, the potential oil displacement would be 3.8, 14 and 28 million barrels of oil per year, respectively. To provide some perspective, in calendar year 1980, oil imports averaged between 6 to 7 million barrels per day.

Moreover, the above estimates assume there is oil to displace. According to DOE officials, the high cost of oil and the Powerplant and Industrial Fuel Use Act--which provides incetives to move away from oil use--are expected to continue the downward trend on petroleum use by utilities. In its 1980 Annual Report to Congress, the Energy Information Administration (EIA) predicts that utility consumption of oil by 2000 will be reduced to less than 10 percent of the current level, and that remaining oil will be used primarily in gas-turbine peaking units. The EIA predicts that utility consumption of oil will remain at significant levels only if financial constraints prevent utilities from completing new coal- and nuclear-fueled plants, in which case existing oil-fired plants would be required to meet rising power demands rather than be retired as planned.

These estimates are further based on the fact that during the past decades, the percentage of total energy consumption in the United States used as inputs to electricity generation has been increasing, and since World War II has risen from about 15 percent to over 30 percent today. According to DOE, this fraction is expected to continue to rise, achieving a level of 45 to 55 percent in the year 2000.

QUESTION 4:

The GAO report refers to the progress of foreign breeder programs. What has been the French experience with its own breeder program with regard to (1) cost overruns; (2) revised estimates of the capital cost of commercial breeders, expressed as a ratio to the capital cost of light-water reactors; (3) revised estimates of the cost per kilowatt-hour of breeder-produced electricity.

ANSWER 4:

Accurate information on the actual costs of the French breeder reactors is difficult to obtain because the information is closely held by the French government. Accordingly, the only information we were able to collect in response to this question has been obtained from DOE and is somewhat sketchy. According to DOE, available cost estimates can exclude expenditures such as interest on capital and fuel costs, which could be substantial. These limitations should be kept in mind in considering the data provided in the following paragraphs.

The construction cost of the 250 Megawatts electric (MWe) Phenix demonstration fast breeder reactor was about $150 million (excluding interest) or nearly 50 percent more than earlier estimates that had been made. In 1974, the 1200 MWe Super Phenix-I was projected to cost about $400 million. However, while the final costs will not be known until construction is completed in 1983, recent estimates are that actual construction costs could be between $2 billion and $2.6 billion when the plant begins commercial operation.

Regarding the ratio of breeder capital costs to light water reactor capital costs, estimates are that the cost of Super-Phenix I may be about twice that of a similar sized light water reactor if research and development costs are included. For follow-on Super Phenix plants DOE estimates that the costs will be 15 to 20 percent greater than an equivalent sized light water reactor.

The 1990 French goal for the cost of electricity, expressed in 1979 dollars, is $.04/kilowatt hour (KWh) for breeder produced electricity, $.03/KWh for light water reactors, $.05/KWh for coal, and $.055/KWh for oil. As a point of comparison, the 1980 electricity costs in France were $0.19/KWh for nuclear generated electricity, $.029/KWh for coal, and $0.44/KWh for oil.

QUESTION 5:

Did the GAO report consider, on a cost-benefit basis, alternative technologies--such as photovoltaics--that could meet future demand for electricity and the need for oil displacement?

ANSWER 5:

No, we did not do any analysis on the relative merits of breeder reactors versus other emerging energy supply technologies such as photovoltaics. The purpose of our report, as stated in the letter transmitting it to the President of the Senate and the Speaker of the House of Representatives, was to "* * * provide congressional decision-makers with a timely evaluation of the [breeder] 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." Accordingly, we analyzed what, in our opinion, were the key issues surrounding the management of the breeder reactor program as it existed at the time. Our objective was not to evaluate the need for the program, but how best to manage it within the environment that prevailed at that time.

Moreover, as our September 1980 report and earlier GAO reports have pointed out, if a long-term nuclear power supply is desired in this country, breeder reactors are required. 1/ Without this technology, the light water reactors now being used will be no more than an interim energy source. Consequently, in order to maintain a program that can keep open the long-term option, we believe it is necessary to demonstrate that the technology is viable and that there is an industrial infrastructure that can support the technology if and when the time comes to deploy breeders on a large scale. To do so, dictates that a breeder reactor facility should be built and operated at this time. Not to maintain the option implies the phasing out of nuclear power as a long-term energy source and, in our opinion, does not seem to be the most prudent course of action at this time.

QUESTION 6:

Breeder reactors will become commercially viable when the uranium used to fuel conventional nuclear reactors becomes scarce and expensive. What effect would the following efficiency improvements in non-breeder reactors have in extending uranium resources

--modifying existing light-water reactors;

--implementing design improvements in newly constructed light water reactors;

--construction of heavy water reactors, such as the CANDU facility in Canada; and,

--construction of advanced converter reactors?

ANSWER 6:

As your question indicates there are two general directions in which non-breeder reactor developments could move to reduce uranium ore requirements for U.S.-generated nuclear power. One is to develop ways of obtaining more energy from the same amount of uranium in existing and future light water (converter)

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

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

reactors and the other is to develop, license, build and operate new types of advanced converter reactors in the United States, including possibly, the Canadian CANDU advanced converter reactor. A discussion of the impact each of these developments may or may not have on reducing future uranium ore requirements follows.

The main thrust toward LWR fuel efficiency improvements by DOE has been to develop fuels that will increase the fuel efficiency of light water reactors 15 percent by 1988 and another 15 percent by the year 2000. DOE intended that 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.

In preparing our report, 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 program official told us, however, that while fuel improvements in 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 the officials we spoke with generally agreed that while 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.

Moreover, a recent GAO report--issued after our September 1980 report--states that DOE has dropped further consideration of its fuel efficiency goals for the year 2000. 1/ In

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1/Letter report to the Chairman, House Subcommittee on Energy Research and Production, Committee on Science and Technology on DOE's light water fuel utilization improvement program; EMD-81-51, dated March 23, 1981.

our opinion, this action further undermines the achievability of significant uranium ore savings over the coming decades and, thus, contributes to the need for prudent planning in determining the need for and pace of the DOE breeder reactor development effort.

Regarding advanced converter reactors, our report points out that DOE believes 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 Canadian heavy water reactor.

However, a proposed fiscal year 1981 budget recision now before Congress, if adopted, would reduce funding for the high temperature gas-cooled reactor to a nominal level 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 Nonproliferation Alternative Systems Assessment Program report, completed by DOE in December 1979, concluded that as a group, advanced reactors seem to offer only modest benefits in resource use. For these reasons, it seems questionable that natural market forces alone could be expected to commercialize advanced converter reactor systems.

QUESTION 7:

When Public Law 91-273 was enacted in 1970 to provide for the Clinch River LMFBR, projections of electricity demand, uranium supply, new nuclear construction requirements, the capital and operating costs of commercial breeders, and the lead time from construction of the CRBR to the commercial viability of breeder reactors were different than they are at present. The GAO report is unclear as to if, and how these estimates have changed.

Please provide a symmetrical comparison of the following so that Members may compare the most recent projections with those made at the inception of the CRBR project in 1970

--uranium supply (please include the effect on supply projections of enhanced recovery techniques, higher prices, and improvements in the efficiencies of non-breeder reactors);

--electricity demand;

--the demand for new nuclear-generated capacity;

--the projected capital cost of commercial breeders, expressed as a ratio of breeder to LWR costs;

--the projected operating costs of commercial breeders;

--the projected cost-per-kilowatt of breeder-generated electricity;

--the lead time from construction of the Clinch River LMFBR to the commercial viability of breeder technology.

ANSWER 7:

Because of complex interrelationships among the various factors included in this question, and because of the great many other variables that must be considered in fully responding to this question, we do not think the answers are conducive to presentation in a symmetrical or tabular format, as you requested. Consequently, our response is in a narrative format. Nonetheless, we think it is responsive to your concerns.

Uranium supply

Generally, estimates of the quantity and quality of uranium reserves and potential resources provide the basis for assessing uranium supply for nuclear power needs. But, according to DOE, the amount of nuclear generating capacity that can be supported by domestic uranium resources cannot be determined by simply equating estimates of total uranium supplies to total demand over a given period. For one thing, it ignores the possibility of an export market and the influence of foreign producers of uranium. In fact, as with other mineral commodities, future uranium production will tend to approximate demand. This was true in 1970 and it is true today. Domestic prices will be influenced by production costs, uranium supply, and foreign sale prices. The interplay of supply, demand, and price is strongly affected by the longer term outlook for nuclear power growth, for which the breeder is an essential ingredient. This situation has altered considerably in the past 7 years.

According to DOE, from 1974 to 1976, there were sharp increases in utility uranium purchases along with rapid price increases. These factors encouraged intense uranium exploration, development, and facility expansion through 1979. Annual production of uranium concentrate (U308) rose from 11,500 tons of U308 in 1974 to 18,700 tons in 1979, with about 20,000 tons projected for 1980. At the same time, estimates of uranium resources available also rose. For example, the resources in the $50/lb forward cost catetory (in 1980 dollars) rose from about 2.5 million tons of U308 in 1974 to about 3.5 million tons in 1980. However, according to DOE, domestic uranium producers currently are curtailing exploration, facility construction, and uranium production because of declining uranium prices, reduced demand, and possible foreign competition. An extended continuation of this trend would seriously restrict domestic uranium production.

As our recent work in this area suggests, if this Nation wishes to maintain a long term future role for nuclear power production, one step that would help reverse this trend and better assure a viable domestic industry would be a renewed commitment to the long-term expansion of nuclear power, the same conditions that argue for the development of the fast breeder.

Obviously, the incremental effects of enhanced recovery techniques, higher prices and improvements in the efficiencies of non-breeder reactors, if they all occur will delay any breeder need date. However, just how much time these factors can buy is, at this point, a very speculative estimate and, we believe, underlines the need for prudent technology development planning for the long term.

Electricity demand

Since the inception of the Clinch River project, the demand for electricity has continued to climb although at a reduced rate. The year Clinch River was initiated, electricity accounted for around one-quarter of total energy used in the United States. At that time, it was forecast that the electrical fraction would grow to one-third in 1980 and one-half in 2000. This prediction has been accurate so far. In 1980, according to DOE, electricity accounted for about 33 percent of total energy and at least some current forecasts predict a 2000 fraction of 45 to 55 percent.

Demand for new nuclear generating capacity

At the time Clinch River project was authorized it was estimated that there would be 1,200 gigawatts of nuclear capacity by the year 2000. It is now estimated that there will be about 200, and possibly less, gigawatts by that time. The primary reasons for the steady decline appear to be (1) the decreasing demand for electricity, (2) the high cost of financing, and (3) the uncertain regulatory climate that prevails over the nuclear power industry.

Projected costs

According to DOE, in 1971 it estimated that the fast breeder reactor would have capital costs about 10 percent higher than LWRs. Over the past decade, various sources have estimated the LMFBR/LWR capital cost ratio to be anywhere from 1 to more than 2. Recent estimates by DOE are that the ratio will be about 1.3.

Originally, it was estimated that LMFBRs would have operating and maintenance costs less than 10 percent higher than for LWRs. In recent estimates, breeder operations and maintenance costs were about 17 percent higher.

In early cost/benefit analyses, total power costs for the breeder were estimated to range from about 3.5 to 4.4 mills per kilowatt-hour. In recent studies, the costs of LWR power were estimated to range from about 20 mills per kilowatt-hour at current uranium prices to more than 30 mills per kilowatt-hour at $200/lb. of U308. According to DOE, nominal breeder power costs are expected to range from about 30 mills per kilowat-hour at current uranium prices to 25 mills per kilowatt-hour at $200/lb. of U308.

Commercial viability

When breeders will become competitive with LWRs is subject to uncertainties in a number of key factors that include uranium supply and price, relative capital costs, and the demand for electricity. Actual commercial viability will depend on decisions made in the marketplace by reactor suppliers and utility buyers. The Federal role is to assure technological viability in a time frame such that the marketplace can make commercialization decisions. Current DOE estimates of competitiveness of LMFBRs with LWRs suggest that the technical basis should be established by the turn of the century to enable the industry to accomplish the commercialization process in a timely manner.