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REPORT BY THE

Comptroller General

OF THE UNITED STATES

Comments On The Administration's White Paper: "The Clinch River Breeder Reactor Project-- An End To The Impasse"

On May 11,1979, the administration issued a White Paper supporting the need to terminate the Clinch River Breeder Reactor for economic and technical reasons. ~~Subsequently,~~ a ~~congressional committee as~~ked GAO to respond to a number of questions regarding the White Paper.

GAO found that the administration's presentation of several key issues and facts in the paper could have been more balanced and informative. In particular, adjustment to key assumptions regarding uranium availability and the capital cost ratio between breeder reactors and light water reactors would materially affect the basic conclusions reached in the paper.

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EMD-79-89

JULY 10, 1979

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

B-164105

The Honorable Mike McCormack
Chairman, Subcommittee on Energy
Research and Production
Committee on Science and Technology
House of Representatives HSE03512

Dear Mr. Chairman:

As a result of hearings on uranium availability before your Subcommittee on May 31, 1979, you asked us if we could respond to several questions on the administration's White Paper document entitled, "The Clinch River Breeder Reactor Project--An End to the Impasse." Later, on June 1, 1979, you sent us a letter confirming your request and specifying the questions you wanted answered. Subsequent discussions with your office further clarified the scope of the information to be provided. A list of the questions and our responses is enclosed.

While the White Paper was issued on May 11, 1979, 4 days after the issuance of our report entitled, "The Clinch River Breeder Reactor--Should the Congress Continue to Fund It?", we were familiar with most of the material presented in it. The Department of Energy provided us with much of the additional factual material we needed and was generally most cooperative.

The overall conclusion ~~to be drawn from our work~~ is that the White Paper's presentation of a number of key issues and facts could have been more balanced and informative. In particular, adjustments, ~~which we believe reasonable~~, to key assumptions regarding uranium availability and the capital cost ratio between breeder and light water reactors would materially affect the basic conclusions reached in the paper.

Sincerely yours,

Elmer B. Staats

Comptroller General
of the United States

FOLLOW-UP QUESTIONS AND GAO RESPONSES FROM MAY 31, 1979, TESTIMONY BEFORE THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

ENERGY PLANNING

1. Please comment on the adequacy of the analysis presented in Chapter II of the White Paper. Specific comments on the methodology and validity of the assumptions utilized in the analysis would be most helpful.

The analysis summarized in Chapter II of the White Paper is slightly rephrased from that which was presented in the paper "The Nuclear Strategy of the Department of Energy." The analytic approach taken was to define a large number of different cases, which spanned a range of values for each of the most significant variables in question--the rate of nuclear growth until 2000, the rate of growth after 2000, the deployment strategy for advances in converter reactors, the amount of uranium in the U.S. resource base, and the ratio of capital costs between breeders and light water reactors (LWRs). For each of these cases a transition date was calculated, as the year in which the next reactor to begin operation would have to be a breeder, either because of exhaustion of the domestic uranium supply ("finite ore model") or because a breeder would be less expensive than another LWR due to increasing fuel costs ("economic model").

While the assumptions made for nuclear growth rates span the ranges currently regarded as plausible, assumptions made for the other variables range from doubtful to highly questionable. The direction of this bias is such as to lean toward conclusions that support the administration's previously stated position--that there is enough time for the United States to delay breeder development.

To illustrate this, the economic model takes three values for the capital cost ratio: 1.25, 1.50, and 1.75, i.e., it assumes that breeders will be either 25, 50, or 75 percent more expensive than LWRs. It attributes these values to the Nonproliferation Alternatives Systems Assessment Program (NASAP) data base. We have subsequently been told by NASAP staff at the Department of Energy (DOE) that these values were chosen arbitrarily, and that more recently NASAP has been using 25 to 50 percent as the likely range for the capital cost premium to be paid for the breeder. Simply making this change would mean that the one-third of the transition dates which are most favorable to breeder delay would be eliminated.

There are two major independent studies we are aware of which have looked at breeder/LWR capital cost ratios. We know that a great deal of other work has been done to support particular positions in this vexed debate, so we emphasize these studies precisely because they were carried out to obtain views that would be independent of possible institutional biases in Government agencies. The Electric Power Research Institute (EPRI) has also studied this issue.

The Battelle study

One of the independent studies entitled, "Study of Advanced Fission Power Reactor Development for the United States," dated January 1976, was prepared by Battelle Columbus Labs for the National Science Foundation's Office of Energy R&D Policy. The Battelle study separately analyzed the individual sub-accounts into which the costs of a nuclear powerplant are broken down, and then combined the results to give an estimated cost ratio. Their conclusion was that the best estimate for the liquid metal fast breeder reactor (LMFBR)/LWR cost ratio was 1.12, with a potential range between 1.0 and 1.15, i.e., the estimate was that an LMFBR would most likely be 12 percent more expensive, but that this cost disadvantage could range between 0 and 15 percent. It should be pointed out that all estimates made or cited in the Battelle report are for eventual commercialized plants, and, therefore, exclude first-of-a-kind or learning costs.

CONAES Resource Group report

The second independent study is the Breeder Reactor Group Report, dated February 1977, which is an unpublished report provided as input to the National Academy of Science's Committee on Nuclear and Alternative Energy Systems (CONAES).

The CONAES Resource Group took the same approach as the Battelle study, i.e., of examining individual component differences between LMFBR and LWR plants. Their report separately treated the Nuclear Steam Supply System (NSSS) and Balance of Plant, pointing out that the NSSS cost for an LWR amounts to about 20 percent of the total plant cost. Their expectation was that the NSSS cost for an early LMFBR would be two to three times that for an LWR, but that the Balance of Plant cost would be only about 10 to 20 percent higher. As a result, they concluded, early commercial LMFBRs would exhibit capital cost penalties of about 30 to 60 percent compared to LWRs.

They further indicated that considerable cost savings could be expected for later LMFBR plants, particularly in the cost of the NSSS. Their conclusion was that a mature LMFBR, at the same stage of development as a LWR being committed in the 1980s, would be likely to have a capital cost penalty approaching 25 percent of a similarly sized and located LWR.

EPRI report

While EPRI has been deeply involved in LMFBR development, the study "Relative Capital Cost of the LMFBR," presented at an April 1976 conference by M. Levenson and P.M. Murphy of EPRI, and C.P.L. Zaleski from the French organization Technicatome, makes very useful contributions to understanding LMFBR/LWR cost differences.

The report compared actual experience in the construction of early U.S. LWRs and sodium-cooled reactors, and concluded that the maximum difference was 38 percent, less the costs that could be attributed to differences in construction dates, degree of innovation, and organizational objectives of the builders. It also examined French experience and found that the cost difference between the first French LWR and the Phenix LMFBR was a negligible 1-1/2 percent, once the costs of engineering both plants and the cost of a specialized research facility at Phenix were subtracted to allow for the contrast between the non-innovative nature of the French LWR as contrasted to the special costs of Phenix as a true prototype machine. They noted, however, that different business climates and organizational structures for the two machines likely favored the Phenix, so that actual cost differences might be somewhat larger than 1-1/2 percent. The report concluded that the most likely capital cost difference between fully developed commercial-sized LMFBRs and LWRs would be less than 20 percent.

Given the conclusions of these three studies, we believe the capital cost assumptions made in the DOE strategy paper are highly questionable. The use of assumptions consistent with these studies would have altered the results of the economic model, enough to indicate the need to start the first LMFBR technical demonstration plant now.

Our testimony and our May 7 report 1/ similarly examined the validity of the uranium supply assumptions used in the finite ore model. While there is controversy about the correct value of the uranium resource estimate, there is clear agreement among experts that in a set of estimates, the higher estimates are less probable than the lower ones. Page 50 of DOE's strategy paper uses what it called a simple analysis, which "treats all future events as equally probable," and is, therefore, using an invalid assumption in its finite ore model also. Our testimony pointed out that emphasizing the most probable cases in the finite ore model again would lead to a conclusion opposite to the one the White Paper offers.

In summary, we believe the analytic methods used to support the White Paper's Chapter II are useful. However, independent experts' views indicate that certain key assumptions used in the analysis are questionable. Moreover, the use of other assumptions we believe reasonable would significantly alter the main conclusion of the White Paper.

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2. It appears that the administration's White Paper did not consider information contained in recent DOE testimony before Congress that shows a shortfall in domestic uranium production in the mid-1990s. Is this true? If so, please comment on the impact this omission has on the adequacy of the presentation contained in the White Paper document.

DOE's Assistant Secretary for Resource Applications testified on February 14, 1979, before this Subcommittee concerning the uranium enrichment and uranium resource assessment programs. In his testimony he included projections of uranium supply and requirements through the balance of this century. The projections in his Chart 11 (see page 5) appear to show a small shortfall of uranium beginning after 1997, with a total magnitude in the range somewhat under 10,000 tons of U_3O_8 over 4 years. However, this should be compared to projected use over those 4 years of more than 250,000 tons, to make clear that this potential shortfall is only some 3 or 4 percent of requirements. It is our view that projections two decades ahead should not

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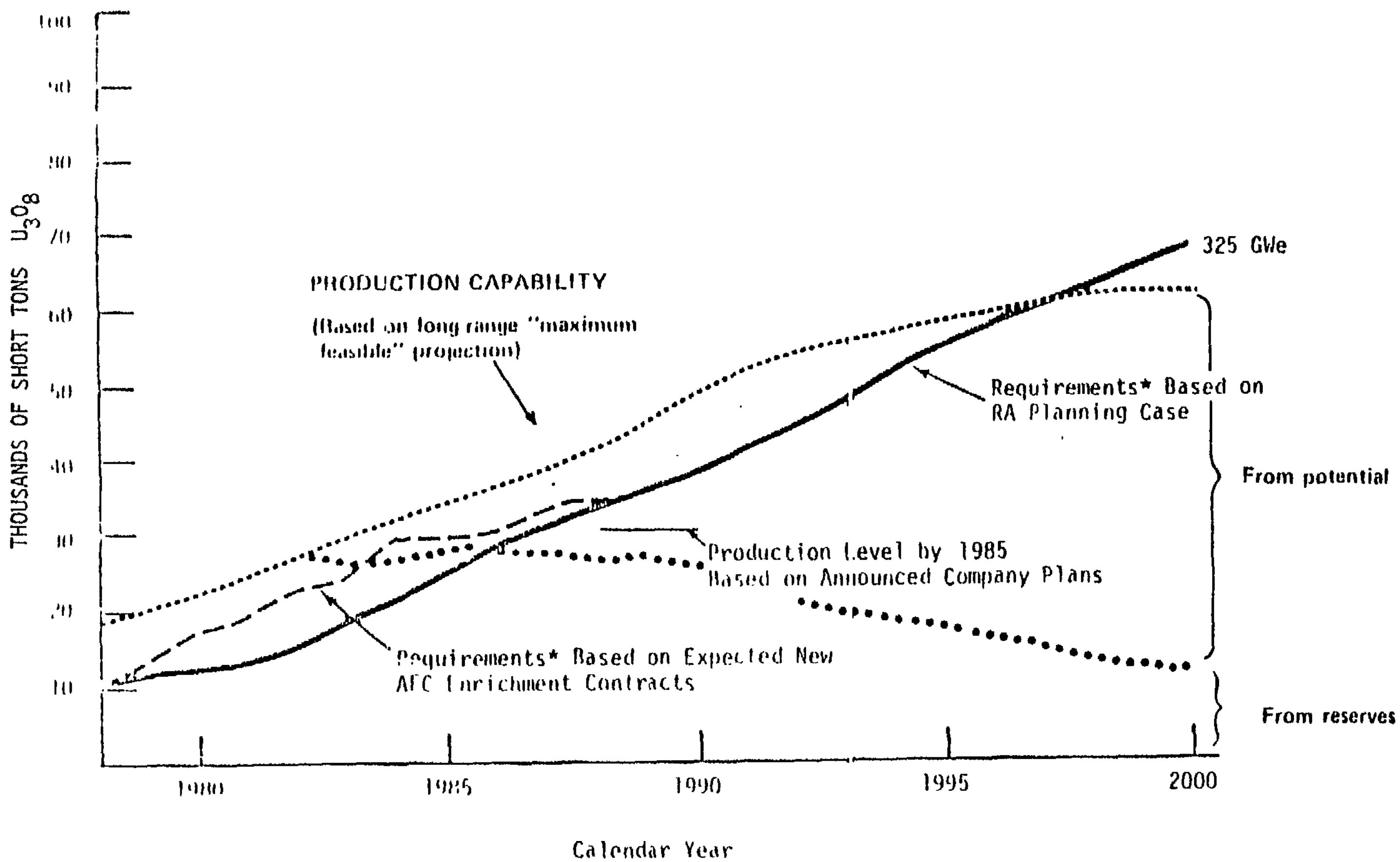
1/"The Clinch River Breeder Reactor--Should the Congress Continue to Fund It?" (EMD-79-62, May 7, 1979).

CHART 11

RELATIONSHIP OF ANNUAL URANIUM REQUIREMENTS TO PROJECTED INDUSTRY PRODUCTION CAPABILITY

Enrichment Tails Assay @ .20%



*Net imports & inventory drawdown have been subtracted

Source: Testimony by DOE's Assistant Secretary for Resource Applications before the Subcommittee on Energy Research and Production, House Committee on Science and Technology, Feb., 14, 1979.

APPENDIX I

be expected to be precise enough to be read to this fine a level, but rather should be examined to detect major trends.

The significant trends in the data considered in the chart show a steadily continuing rise in uranium requirements, contrasted to a relative leveling out of production capability, which would suggest a gap that could grow to significant size in the beginning of the next century. However, the chart indicates that the amount of U_3O_8 required for the balance of this century is about 800,000 tons, which is less than present estimates of uranium reserves alone, without considering any of the potential resources. Thus, the possible shortfall would not result from limited resources but rather because of the rate at which known uranium in the ground can be mined and prepared for use. Thus, because the White Paper considers only uranium resources and not mining and milling capacity, the estimated shortfall in uranium production does not have a direct bearing on the Paper's treatment of the question of breeder timing.

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3. Please comment on the DOE claim that some newer mills, designed to treat low-grade ores, have been attaining very high recovery rates, as high as 97 percent.

There are some new uranium mills whose recovery rates for low-grade ores are significantly better than the average recovery rate for all mills. However, other new facilities have recovery rates that are worse than the average recovery for all mills, new and old. Our discussions with the industry indicate that recovery rates for one of these efficient new mills is expected to decline to the mid-80 percent range as ore grade declines. While it is plausible that new mills and new mill technologies could be significantly better than current experience, we believe that, at this time, prudent planning should not rely on recovery rates reaching 97 percent for new mills and low-grade ores. We would point out that neither does DOE when it did its most recent uranium producibility estimates. Their method of estimation would indicate a mill recovery of about 87 percent for U.S. uranium resources.

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4. Please comment on the extent to which the "new technological opportunities" identified in the administration's White Paper on the CRBR (Clinch River Breeder

Reactor), can extend uranium fuel efficiency. I would like you to discuss the following areas at a minimum:

--What happens if the "new technological opportunities" are not implemented to the extent expected?

--What is the effect on uranium supply, if any, of steps taken by industry to shift to fuel cycles that consume more uranium than current LWR plants? (For example, TVA's plans to go to an 18-month cycle.)

--Will the savings realized by these fuel cycles be enough to offset losses? (Please include comments as to whether the savings will be enough to offset the loss of uranium in the milling process which GAO recently pointed out to DOE in a letter dated April 10, 1979.)

The new technological opportunities discussed are: (a) advanced isotope separation (AIS) techniques which, it is hoped, will extract more U-235 from natural uranium and thus lessen ore requirements for the same amount of enriched fuel, and (b) changes in LWRs, and/or the introduction of advanced converter reactors which would require less uranium ore for fuel.

Neither of these improvements is available in the United States at this time, although the heavy water reactor, which now requires less than 80 percent as much uranium as the LWR, is successfully commercialized in Canada.

<u>Advanced isotope separation (AIS)</u>

AIS is described by DOE as offering the possibility of extending uranium resources by 14 to 19 percent.

Development of AIS is being pursued in several places in the United States, and we understand that one private organization is now in the process of deciding whether to build a first small scale laboratory demonstration unit.

The DOE program in AIS is at about the same stage of evolution as the private program, well along in applied research and preparing to consider a laboratory demonstration (DOE's system for describing stages of research, development, and demonstration (RD&D) calls this next stage "technology development"). DOE plans currently call for a commercial demonstration plant to begin operation in 1993, with a first production plant to begin operation 2 years later in 1995.

However, the DOE program plan for AIS is extremely optimistic in its schedule, with each of four units (laboratory demonstration, technical demonstration, commercial demonstration, and first production plant) scheduled to begin construction before its predecessor has begun operation. A more realistic schedule would add over 10 yeras to the 1995 estimate for operation of a production plant, by allowing time for each developmental stage to be completed and in operation for a year or two before the next stage began construction, thus allowing the operating experience gained in each stage to influence the next stage. If a commercial operation date beyond 2005 is the earliest that can realistically be expected for AIS (and that, only if the development program proceeds without problems), than clearly AIS cannot be depended on to extend uranium resources starting in the 1990s. While it is true that commercial start-up of AIS in the 2005-2010 time span could still contribute usefully to meeting fuel demands for reactors beyond the 386 gigawatt-electric (GWe) limit currently implied by the uranium resource planning base chosen in the White Paper, we think it unlikely that utilities would be willing to be committed to building reactors which had to depend for fuel on a technology which has not yet been proven.

Improved efficiency in converter reactors

There are two major directions in which developments could move to reduce uranium requirements for the United States' converter reactors. One would be to develop ways of obtaining more energy from the same amount of uranium in LWRs and the other would be to develop, license, build, and operate new types of advanced converter reactors in the United States.

The major thrust toward LWR uranium efficiency improvement is the new effort, supported by DOE, to develop fuels which can run for longer times, i.e., achieve higher burn-up, in existing LWRs.

Present LWR fuel is discharged after giving an average of 25,000 to 33,000 megawatt days of energy per ton (MWD/T). First tests are now underway to try to obtain 38,000 MWD/T or more from some fuel, and plans are now being made to develop fuel which could achieve a burn-up of 45,000 MWD/T.

The extension to 38,000 MWD/T is essentially an attempt to stretch out the life of the current type of fuel, while the 45,000 MWD/T effort involves design and development of new types of fuel.

The test of higher burn-up of present fuel is scheduled to be completed late this year, after which it will have to be evaluated, while the program for 45,000-MWD/T fuel is on a much longer schedule. A first set of "conservative" test assemblies is scheduled to be run from late 1980 until 1985, and a second set of "optimized" assemblies is scheduled for insertion in mid-1982 for irradiation until 1986. The information from these two sets of assemblies is then intended to be used to design and demonstrate an entire reload batch, which we assume will have to be run for a similar 4- to 5-year period. If these tests are successful, then by the mid-1990s a substantially improved LWR fuel could be ready for use, and it could probably be deployed in the ensuing years in all existing and new LWRs.

The reduction of uranium requirements which could come from these increased burn-ups will be significant, but it cannot be calculated directly from the longer burn-up achieved, because there will be a need to use more highly enriched fuel.

A DOE official has told us that the additional enrichment requirement means that a burn-up level of 45,000 to 50,000 MWD/T would be needed to obtain a net increase of about 15 percent in uranium efficiency, the first improvement which is mentioned in the White Paper. If the tests and development programs proceed on schedule, and are successful, then this improvement could only reasonably be expected to be entering widespread deployment by the later date suggested in the White Paper, i.e., the late 1990s or 2000. The next improvement in LWR efficiency, this official told us, would involve steps which could only be applied in a small fraction, possibly 20 or 25 percent of existing LWRs.

In summary, DOE plans would indicate to us that the first step of DOE-supported uranium efficiency improvements for LWRs, amounting to about 15 percent, will be available at the earliest in the middle to late 1990s, and that this step would likely be applicable to all LWRs. There is the possibility that industry could make this step occur more quickly. A DOE official indicated that this appeared likely as an outgrowth of competition among fuel suppliers, but we have not attempted to evaluate this prediction.

The next step, which the White Paper speaks of as an additional 10- or 15-percent improvement, would appear likely to have a much smaller impact on uranium supplies if, as the DOE official estimated, it would only be applicable to new reactors and a small fraction of existing reactors. This is because, by the time the step is ready, there would already be a large number of reactors operating which would not be able to capitalize on the improvement.

One cautionary note is required here, however. Your question also asked about the effect of the shift to an 18-month refueling cycle that industry is considering. We have been told by fuel supply officials in industry that this step, under consideration because it would reduce the amount of time that reactors are shut down for refueling, would require more highly enriched fuel. Their calculations indicate that the amount of U_3O_8 which would be consumed to produce this fuel could be 10- to 15-percent greater than used under current refueling practices. Thus, as with enrichment planning, there are competing technical demands which could exert upward pressure on uranium requirements for reactors and thus might balance out a significant part of the anticipated reduction in uranium demand for existing and planned LWRs.

If both the 18-month refueling cycle, with its 10 to 15 percent increase in uranium demand, and the increase in losses of uranium from milling (currently at about 9 percent and likely to grow to as much as 15 percent even in new mills) are balanced against the improved efficiency coming from longer burn-up, then the net effect would be that uranium requirements would be increased somewhat even after the 45,000-MWD/T fuel became available. At about the same point, uranium requirements for new LWRs could be reduced somewhat from the present level, but at best only to about the level, approximately 5,500 tons of U_3O_8, which is that currently in use in DOE planning. If the 18-month cycle is not put into use, then the 45,000-MWD/T fuel, if successful, could about compensate for mill losses, while the additional steps for new reactors, if demonstrated successfully, could make possible an actual reduction of LWR uranium requirements for subsequent reactors below the level presently in use in DOE planning, by the order of 10 to 15 percent.

DOE's development of advanced converter reactors has actually retrogressed recently, with the DOE proposal for FY 1980 to withdraw support from current gas-cooled reactor development, and to shift attention to direct turbine and/or process heat uses of the high temperature gas reactor (HTGR). The only HTGR in the United States is the intermediate size Fort St. Vrain reactor, which has had a very slow start-up period that was still underway several months ago, 2 years or more behind schedule. Fort St. Vrain is a steam cycle HTGR, so a development which switches to a different cycle (direct turbine or process heat) would likely have to re-do the intermediate size development stage, and, therefore, would take at least one more design and construction cycle (about 12 years) before being ready for deployment on any significant scale. This would seem to mean that deployment of this type of advanced converter could not begin until after the turn of the century. The other potentially available advanced converter, the Canadian type heavy water reactor, is still not being supported for design or licensing in the United States as of the January 1979 Draft of DOE's Fission Energy Program.

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5. Is the cost of electricity as assumed by DOE for an oil-fired plant in the year 2000 consistent with GAO estimates or industry estimates? Please provide similar information for a coal-fired plant, a LWR, and a breeder.

In responding to this questions, please comment on the following conditions:

--What happens if there is insufficient fuel for a utility to use in a plant for its expected 30- to 40-year life?

--At what point will it become necessary for a utility to decide to go to the next most expensive option?

--On what basis would a utility make a decision to go nuclear in the mid- to late-1980s for a plant to be in service by the late-1990s?

--To what extent does demonstrated technology and an understanding of fuel economics and availability impact on a utility's decision to go nuclear?

The energy technology data sheet prepared by DOE which was printed in the Congressional Record for May 23 (pages S6566-8) does not show any estimates of either supply or cost for oil-fired electricity generation. This implies that DOE is not expecting any new oil-fired electric power as of 1990, which we believe is an expectation likely to be met. In our report "Questions on the Future of Nuclear Power: Implications and Trade-Offs" (EMD-79-56, May 21, 1979), we projected future electricity supplies assuming that oil- and gas-fired generation would remain constant through 1985 and then decline linearly until it was entirely phased out by 2000.

While there are not many detailed projections of electricity fuel sources to 2000, the trend of most other projections through 1990 for oil- and gas-fired generation shows a somewhat steeper decline than our assumption, falling off by 40 percent from 1976 levels compared to a decline of only 33 percent in our more conservative projection. Either of these trends suggests that oil-fired facilities will make very little or no contribution to U.S. electricity supplies by 2000. If some oil-fired generating capacity does remain in operation at that date, we anticipate that it will only be used to meet special regional, technical, or environmental constraints. We think it likely that major efforts will have been made to meet even these demands with other types of generating capacity, in light of the high likelihood that the world oil supply will have begun to decline before the end of the century.

Projections of electricty costs from other sources were made in the DOE data sheet only to 1990. We have not evaluated those projections in detail, but we would note that they do show a reasonably wide range for each source, with ranges of 40 to 60 percent for well known technologies and some ranges for other less well known technologies as great as 100 percent.

The lowest cost projections in the data sheet are the minimum values for low head hydro, at 20 mils per kilowatt hour (kwh), and LWRs and two coal technologies at 25 mils per kwh. It seems to us that the relative ranking of these costs is reasonable.

We would, however, add several cautionary notes. First, even the maximum projected supply of low head hydro in 1990, some 50,000 barrels oil equivalent per day, is quite small, corresponding to the relatively small overall size of this desirable but very limited resource.

Second, we would anticipate that the increased safety concern with nuclear power, in the wake of the Three Mile Island accident, might well result in additional steps being taken in the licensing, construction, and surveillance of nuclear plants, which could increase their costs.

In choosing among the options available for new generating capacity, utilities generally must make decisions faced with uncertainty in many factors. Included in these uncertainties would be the future level of demand in their service area; the costs of construction, which may change significantly between contract signing and completion due to inflation, changes in regulations, and delays from any number of sources which raise the costs of interest during construction; and the future cost and availability of fuel. It seems clear that any option which can offer reduced uncertainty is likely to have an advantage in this decision process.

Technologies which have not been fully demonstrated will stand at a disadvantage in this competition, since utilities will need reliable supply from plants they build, and generally cannot afford to risk investments on plants of unproved reliability. Similarly, reliability of fuel supply will be critical to a utility, because a plant without fuel would be a wasted investment. The future price of fuel may not be as critical a determinant of investment decisions, especially if the fuel adjustment charge continues to allow fuel costs to be passed through to consumers.

Regarding nuclear plants, the concern about uranium resources and, even more significantly, the possible limits to rates of uranium output, are likely to have an impact on utility decisions if they raise the uncertainty of fuel supply to too high a level. It is in this context that we consider it likely that conservative estimates, like those by the Uranium Resource Group of the National Research Council's CONAES study, are likely to be given the greatest attention. If uncertainty of fuel supply becomes too great, then we would anticipate that utilities might choose somewhat more expensive options which did not face such uncertainty.

Further modifying utility choices will be the effects of public concern or doubt about other, possibly noneconomic, features of different electric supply options. Salient among these, at least for the present, is the opposition to nuclear power due to doubts, however valid, of its safety. If opposition is likely to cause delays in the licensing or construction of a nuclear plant, a utility may well choose another alternative, even if it is more expensive, if the other plant can be available on a more predictable timetable.

Utility decisions in the middle to late 1980s, for plants to begin service in the late 1990s, will likely face most of the same questions we have noted here. Their fuel supply expectations for nuclear plants will be formed by the state of knowledge at that time of future uranium resources, reserves, and supply rates. It is for this reason among others that we have continued to urge major efforts to complete the National Uranium Resource Evaluation as thorougly and quickly as possible.

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6. Please comment on the change in perceptions of the need for breeder development as discussed in the section on pages I-2 and I-4 of the White Paper.

The White Paper is correct in arguing that perceptions of the need for the breeder have changed since 1970, particularly because estimates of nuclear generating capacity to become available in this century have diminished substantially. However, the White Paper does not give a proper historical perspective on the uranium resource question, nor does it properly take into account the effects on uranium demand and electricity supplies likely to come from the use of coal for synthetic fuels, which is anticipated over the balance of this century.

A paper written in 1974 1/ pointed out that the decision on whether, or when, to exploit advanced converters and breeders would depend strongly on the circumstances in individual nations. In some nations the decision could be very straightforward. Very uranium-rich countries, like Canada or Australia, could continue using uranium-intensive converter reactors for a long time. On the other hand, uranium-poor countries with few energy resources of any kind, like France or Japan, would be driven to pursue the breeder very quickly.

The United States is not in either class. It has significant quantities of uranium and other energy resources such as coal. As a result, the decision to commercialize the breeder is not so clear cut, resting on a complicated set of assessments of the U.S. energy situation.

Need for nuclear power

In our recent report assessing the need for nuclear power, 2/ we pointed out that any severe curtailments in

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1/Summary of Presentation on Advanced Converter Strategy in the U.S., E.L. Zebroski, Annals of Nuclear Energy, Vol. 2, pp. 741-744 (1975).

2/"Questions on the Future of Nuclear Power: Implications and Trade-Offs" (EMD-79-56, May 26, 1979).

nuclear growth could only be accomplished at the expense of diverting large amounts of coal to electricity generation, thus curtailing coal availability for other uses, and at the same time, requiring constraints on the growth of electricity demand. Today's gas lines and the growing fear of home heating oil shortages this winter have resulted in a growing movement to develop a large industry to make synthetic oil and gas from coal. Legislative proposals envision Manhatten-type projects aimed at developing a synthetic fuels industry producing from 2 to 5 million barrels a day of oil or its equivalent by 1990.

Without evaluating the likelihood of achieving any goal within this range from a technical standpoint, we would point out that accomplishment would be virtually impossible without an expansion in nuclear energy to free-up coal for use in a synthetic fuel industry.

Adequacy of domestic uranium

In the period shortly after World War II, when development of nuclear energy for electric power first began, it was feared that military needs would severely limit the amount of uranium available for civilian use. As a result, significant early efforts were focused on breeder reactors so that a civilian power industry could fuel itself. Indeed, the first nuclear reactor ever to generate electricity was of the breeder type.

As uranium supply became less constrained, attention shifted to other types of reactors. The U.S. LWR and Canadian heavy water reactors were developed and commercialized. Through this time, however, the concept of an eventual shift to breeders remained fixed, since it was widely recognized that (1) economically recoverable uranium was a finite resource, and (2) the fuel resources for fission reactors could be multiplied 100-fold or more by turning U-238 and/or thorium into fissionable fuels. The date of transition from a converter reactor industry to a breeder reactor industry was a function of the ability of the economically recoverable uranium resource base to meet U.S. nuclear power growth.

To better assess the extent of the U.S. resource base, the United States initiated the National Uranium Resource Evaluation (NURE) program. The White Paper is correct in focusing its attention on the question which NURE seeks to answer, but it misrepresents both the present level of our knowledge on this question, and the trend in actual estimates over the past several years.

In February testimony on NURE before this Subcommittee, DOE's Assistant Secretary for Resource Applications said

> "At this stage, it is too soon to draw conclusions regarding the national assessment * * * Until we can complete more of these [evaluation and assessment] studies and integrate findings, it would not be prudent to specualte on or attempt to predict the results."

This contrasts sharply with the White Paper's use of the estimates to argue that the time when a breeder will be needed has been pushed back to 2020 or later.

In addition, the White Paper asserts that "* * * our estimates of the amount of uranium ore available have grown considerably," which we regard as misleading. The two major changes in DOE uranium resource estimates in the past several years have been the inclusion of higher cost (lower grade) ore categories in the estimates, and the progressive decline of most estimates for particular categories. The DOE estimates as of January 1, 1979, are as follows:

	Millions of tons U_3O_8 by forward cost category		
	$15	$30 (note a)	$50 (note a)
Reserves	.290	.690	.920
Potential Resources			
Probable	.415	1.005	1.505
Possible	.210	.675	1.170
Speculative	.075	.300	.550
Total	0.990 b/	2.670 b/	4.145 b/

a/Higher cost classes include all lower cost material.

b/To each of these should be added 0.120 million tons estimated available by 2000 as a byproduct of other mining.

These can be compared to the estimates from January 1, 1976, which are:

	Millions of tons U_3O_8 by forward cost category (Jan. 1, 1976)	
	$15	$30
Reserves	.430	.640
Potential Resources		
Probable	.655	1.060
Possible	.675	1.370
Speculative	.290	.590
Total	2.050	3.660

Thus, in 3 years the estimates of total reserves plus potential resources in the $15 category has dropped by more than 50 percent, and the corresponding total for the $30 category has dropped about 27 percent.

The only reason why a claim could be made that total uranium ore estimates have increased recently is because of the addition as of January 1, 1977, of the $50 forward cost category to the estimates. Yet even that category has most recently shown an overall decline, as can be seen in the following comparison of DOE $50 forward cost figures.

	Jan. 1, 1977	Jan. 1, 1978	Jan. 1, 1979
Reserves	.840	.890	.920
Potential Resources			
Probable	1.370	1.395	1.505
Possible	1.420	1.515	1.170
Speculative	.540	.565	.550
Total	4.170	4.365	4.145

The White Paper focused on a portion of the estimates, $50 reserves plus probable potential resources, which has shown an upward trend, increasing by about 10 percent in the 2 years since data in these categories began being published. But even these increases, according to DOE, were attributable at least in part to conversion from less certain categories rather than purely to finding of new resources.

In summary, the White Paper's description of trends in uranium resource estimates is misleading, and we do not believe that the actual data available to date supports a claim that economical uranium supplies have grown substantially.

We can now make a calculation of the number of LWRs supportable based on the White Paper's suggested figure of 2.43 million tons of domestic U_3O_8 likely to be available. For this we use 6,300 tons, an average of the amounts which we calculate as needed now (6,000 tons) and in the 1990s (6,600 tons) to provide fuel supplies for a 30-year lifetime for a 1-GWe LWR. The division of 2.43 million tons by 6,300 tons per reactor shows that this amount of uranium could fuel about 386 GWe of LWR capacity. The White Paper indicates that the range of nuclear generating capacity by the year 2000 in the United States is estimated at between 255 and 395 GWe. Thus, if circumstances result in sustained growth of nuclear generation within the limits now considered possible, a breeder could be needed even before the end of the century, and only an extremely slow rate of nuclear growth--slower than any cases analyzed in the White Paper on DOE's analyses--could allow delay of the need for the breeder to as late as 2020. On the other hand, should the need for synthetic fuels grow significantly, there might be even more need for nuclear power, with a resulting acceleration of the need for a breeder or an alternate technology.

Finally, we would note in line with a point made in the Ford/Mitre report, "Nuclear Power Issues and Choices," that moving to exploit the lower grade uranium deposits represented by the increment of ore in the $30- to $50-cost range will bring the United States to or near the point where the fuel cost advantage of light water nuclear plants no longer can overcome the capital cost disadvantage they have compared to coal-fired plants. This would leave the actual competition for new electrical capacity to coal and the breeder.

PROJECT TERMINATION COSTS

1. What is the Federal Government's legal liability, if any, to refund industry contributions for the Clinch River Breeder Reactor (CRBR)? How much would this add to the cost of termination? Should the ratepayers be given their money back?

The Federal Government's liability to refund industry contributions to the Clinch River project is unclear. On the one hand, industry's view has been that if the project does not operate, its contributions must be refunded. On the other hand, the Federal Government has maintained that it does not have to return such contributions. This issue may not be resolved until it is litigated.

If the project is terminated as of September 30, 1979, the industry contributions that would have been applied to project costs at that date are about $102.0 million. Accordingly, if the issue of Federal payback for industry contributions is litigated and judged to be in industry's favor, the $102.0 million would be added to the $151.7 million termination costs already identified by DOE. Additionally, as our May 7, 1979, report on the Clinch River project points out, the $151.7-million termination costs could ultimately be as high as $350 million. This higher figure reflects estimates by some industry groups and depends on the results of lawsuits that may be brought against DOE for failing to complete the project.

As to whether the utility ratepayers should be given their money back, there is no easy answer. This question involves a complicated web of interrelated legal issues that would entail a lengthy legal research process that could lead to a long series of court battles. Consequently, we do not believe we can contribute to the resolution of this issue at this time.

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2. What is the GAO's estimates of the costs that are attributable to the administration's delay in completing the project?

We estimate the cost at about $450 million. Our May 7, 1979, report stated that $410 million of the project's total estimated cost was attributable to the stalemate that now exists between the Congress and the administration. However, the $410-million figure was based on a total estimated project cost of $2.494 billion. At the time our report was prepared, we were not certain what portion of the increased cost estimate--$2.643 billion--was attributable to the current policy stalemate. Subsequently, we found that about $40 million of the estimated project cost increase of $149 million was due to this factor. As a result, the current estimate is now $410 million plus the $40 million increment in the increased project cost estimate, for a total estimate of $450 million.

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3.a. What are the GAO's estimates for completion of design, procurement of components for testing, and actual testing of selected components?

Completion of design

For fiscal year 1980, the administration is requesting $20.0 million to continue selected CRBR system design activities of value to the overall LMFBR program. However, the nature and scope of these selected design activities are not yet firm and may change if and when the Clinch River project is terminated. The $20.0 million is included in DOE estimates as part of the $151.7-million project termination cost. For the administration to complete systems design work, industry groups estimate that an additional $30 to $50 million may be needed. This would include all the drawings, procedures for plant startup and shutdown, and a review of facility control board operation. It should be noted, however, that these are rough estimates.

Procurement of components for testing

For fiscal year 1980, the administration is requesting $14.4 million for procurement of components to terminate the project. This represents the costs associated with completion of the pump and pump drive, steam generator, and secondary control rod system. The $14.4 million is included in DOE's estimated termination cost.

The estimates of the amount of additional funds needed for this activity is about $18.8 million. The additional money is for two additional steam generators that will be needed for system testing, an additional pump, an additional secondary control rod system, and other minor items. These represent those components considered useful in conducting further research on advanced fission technology.

Testing of selected components

This category of expenditures is not included in the administration's estimated termination cost of $151.7 million. According to DOE officials, this is because the components selected by the administration will be tested whether or not the Clinch River project is constructed. The costs are currently included in the base program portion of the budget for LMFBR development. However, it has been estimated that to test the already completed components of Clinch River and those additional components mentioned in the previous segment of this question, an additional $50.7 to $60.8 million would be needed.

Further, if it is desired that the intermediate heat exchangers be tested at their full Clinch River capacity, a new testing facility may have to be built at an estimated cost of over $300 million. Without such a facility, these components could only be tested at about 60 percent of their capacity. The prototype steam generator and any additional ones that are to be built could also be tested in such a facility. Currently, the steam generators can only be tested at about 60-percent capacity.

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b. Should these costs be added to the "cost of termination?"

If a decision is made to complete the design of the project and to complete the procurement of components, it appears reasonable that such costs be included as a "cost of termination." As for testing of the components, any additional costs should be treated the same as those already in the DOE budget, i.e., as part of the LMFBR base program, not as a "cost of termination."

However, we would like to point out that we have not addressed the merits of this proposal versus that proposed by the administration. In order to do this, in answering parts a and b of this question, it would be necessary to do a detailed analysis of the merits of the administration's current proposal versus that posed by this question. We do plan to address this question to some degree as part of our future work in this area, which is scheduled to begin in July 1979.

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4.a. Should the cost estimate for CRBR show the revenue to be generated as a result of selling power to the TVA grid?

The Federal Government would operate the Clinch River facility for the first 5 years of its life. During this time it would sell power to the TVA grid which would result in gross revenues to the U.S. Treasury of about $386 million, assuming a 1987 startup date. It is our understanding that these revenues and their associated costs are offset in arriving at the total estimated cost of the Clinch River project, which is now $2.643 billion.

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b. What is GAO's estimate of the revenues to be generated by Clinch River during the first 5 years of operation?

It is estimated by DOE and CRBR project management that about $386 million in revenues would be generated by the Clinch River project over the first 5 years of its operation. At the same time the estimated operating costs for this period are $246 million. Therfore, the net revenue to the project over the 5-year period, assuming 1987 startup, would be about $140 million.

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c. At the current rate of power escalation in the TVA grid (CRBR power purchased at highest cost power assumption) isn't it likely that the project will ultimate pay for itself?

It does not appear that the CRBR will ever pay for itself. However, the actual amount of the difference between cost and revenues varies depending on the assumptions used in determining plant revenues. In any event, it is important to note that the facility, like other demonstration plants, was never intended to "pay for itself."

DOE has estimated that the gross plant investment for CRBR over its 30-year life would be about $17.6 billion. The estimate includes costs normally incurred by a utility such as interest during construction, return on equity, interest on debt, depreciation, taxes, insurance, and decommissioning costs. The net plant revenues, according to DOE, would be about $4.4 billion for the life of the plant, based on TVA experience in 1977. Further, if it is assumed that the plutonium produced by the CRBR has future value, by 2018, after 30 years of plant operation, the plutonium produced would be worth about $8.1 billion (priced at today's prices of $40/gram). DOE did not factor this consideration into their estimates because it is not clear whether plutonium will have any value in future years. It is impossible to determine, at this time, which assumption is correct.

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d. Should this fact be mentioned in the White Paper?

We believe it is not particularly important to mention the answers to part a, b, and c above in the White Paper. Since the financial information contained in section VII of the White Paper portrays the total Clinch River cost estimate and already reflects the revenue offset for the first 5 years of operation, we see no need to present additional cost and revenue data that may have no direct impact on the Government's expenditures for the project.

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5. Is it the GAO's position that the administration should revise its White Paper to clarify, as did the GAO report, that $830 million of the "project cost" represents first-of-a-kind R&D cost which will be transferred to future LMFBR development benefit?

We believe the White Paper would have been more balanced and more informative if it had mentioned that a large portion of the $2.643 billion estimate for the project is due to first-of-a-kind project costs. The point is significant since these costs represent more of a research and development cost than an actual cost of completing a mid-size LMFBR demonstration plant--the CRBR.

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6. Should the White Paper mention that many of the components for the CRBR have been fabricated and are sitting in storage? Should there be an indication of the dollar value of what may become scrap metal?

There is now about $30 million in components that have been fabricated for the Clinch River project and are sitting in warehouses and other storage facilities across the country. These include such items as cold leg check valves, the core support structure, the pump guard vessel, and the in-vessel transfer machine among many others. The $30-million figure could be as high as $62.8 million by the end of this fiscal year, when it is expected that the reactor guard vessel and some other items will be completed. However, it is not clear at this point which components can and will be used if the CRBR project is terminated.

Consequently, given this uncertainty and given the objective of the White Paper--to assist Members of Congress and their staffs in reaching a decision on whether to terminate the Clinch River project--we do not believe the report is deficient because it did not include these facts. Moreover, these costs, in our opinion, could reasonably be interpreted as being relatively minor in presenting the CRBR cost data.

It is difficult to say at this time whether the costs associated with the already completed components or those that might be completed by the end of the fiscal year should be considered scrap metal. DOE has tentative plans for many of the components if the CRBR is terminated. On the other hand, industry officials involved in the project characterize these components as largely scrap material that will be of little or no use to the LMFBR program. In any event, the dollar value of these components is, in our opinion, a relatively insignificant issue in helping to decide the future of the project.

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7. In view of the above factors, what is the estimate of the total cost that the Government will incur in terminating the CRBR project, expressed as a percentage of the total cost that would be incurred if the project were to continue on schedule?

As the previous answers indicate, there is a great deal of variance and disagreement surrounding the costs to terminate the Clinch River project. Therefore, in responding to this question, we used two sets of figures both of which assume a termination date of October 1, 1979. The two sets of figures are the (1) low-end estimates which are DOE's current estimates for termination costs as a percentage of project completion costs and (2) high-end estimates which are the estimated termination costs from the answers above as a percentage of project completion costs.

Estimate #1 (Low-end)

$$\frac{\$151.7\text{-million termination cost}}{\$1.642\text{-billion cost to complete CRBR}} = 9.2 \text{ percent}$$

Estimate #2 (High-end)

$350.0	million termination cost
102.0	million if Government must pay back the indstry contribution
40.0	million to complete design 1/
18.8	million to procure components
355.0	million to test components 1/
$865.0	million estimated cost to terminate

$$\frac{\$865.0 \text{ million}}{\$1.642 \text{ billion}} = 52.7 \text{ percent}$$

SAFETY ISSUES

1. Please comment on the significance of the administration's failure to include in its evaluation the extensive LMFBR experience in the United States, e.g., EBR-I operation in 1951, EBR-II operation since 1963 and currently providing power to the grid in Idaho. Does the GAO consider these plants safe to operate?

In our opinion the White Paper presentation would have been more balanced had it included a brief discussion of LMFBR experience in the United States.

Chapter VI of the White Paper contains two references to specific operating LMFBR plants, the Fermi plant, which was a U.S. plant that stopped operating in 1973, and the BN-350, a Soviet facility that is still operating. Both references are used to reinforce certain safety issues discussed on pp. VI-2, 3, and 4 of the document. In our opinion a reader of the White Paper is left with the impression that all operating experience with LMFBR plants has resulted in safety problems and has been generally unfavorable. Such imbalance could be offset if a brief discussion of some of

1/These figures represent an average cost figure based on the high-end estimates provided in the answer to question 3a on page 20.

the less notorious features of these projects and other more incident-free projects like the EBR-II facility were included in this paper.

DOE and the Nuclear Regulatory Commission (NRC) believe that both the EBR-I and EBR-II facilities are safe to operate. At this time we have no reason to question their opinions.

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2. It is noteworthy that both the Fermi-I reactor (operated for 2 years) and the BN-350 (now in operation) were both put back into operation following their shutdown. Does GAO feel that this fact should have been discussed to adequately address the safety issue?

Yes. As now written, the White Paper leads a reader to conclude that both the Fermi-I reactor and the BN-350 were permanently shutdown as a result of coolant related accidents at the respective facilities. Such a conclusion is incorrect.

The Fermi-I reactor was put out of service in 1966 as a result of a partial core meltdown due to coolant flow blockage. However, in 1970 the reactor went back into operation. Subsequently, in 1973, the reactor was permanently shutdown because of a lack of financial support for its continuation. Similarly, the BN-350 facility went back into operation after its accident and is still operating today, despite the White Paper statement to the contrary.

It is also worth noting that many technical experts we interviewed in preparing these answers told us that the recent incident at the Three Mile Island facility near Harrisburg, which is a conventional nuclear powerplant and not an LMFBR, was much more serious than the Fermi-I accident.

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3. The administration failed to observe that the CRBR design provides that there are no materials with which sodium can react to form hydrogen inside the reactor vessel. Should the design features be factored into the discussion of the "chemical-reactivity of sodium?" What is the significance of the omission?

We believe that the White Paper should have observed that the CRBR design, as well as any other LMFBR design, provides that there are no materials with which sodium can react to form hydrogen inside the reactor vessel under normal operating conditions. However, we also believe this alone would not be sufficient to provide a balanced, objective presentation of the issue as now discussed on page VI-3 of the White Paper.

The administration's position portrays water as a common, harmless coolant material, whereas sodium is viewed as an alternative reactor coolant wrought with inherent safety problems. In our judgment, a more accurate and more balanced presentation would discuss, or at least refer to, the problems with water coolant as well as sodium. For instance, the containment of high pressure steam that would result from a leak in an LWR coolant system is a problem that is not mentioned in this section of the White Paper.

Moreover, NRC sees the issue of the chemical reactivity of sodium as not being an insurmountable safety issue but an engineering issue that can be accommodated in LMFBR design.

We believe the omission is significant and seriously detracts from the credibility of the document.

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4. The White Paper doesn't discuss the fact that sodium was chosen for the coolant because, among other things, it functions at low pressure and with a high boiling point.

a. Doesn't this leave the reactor in a more protected condition in the event of an accident since the coolant can't boil away?

Sodium can boil away at about 1,700 degres Fahrenheit. Nonetheless, under conditions involving a coolant leak accident, having sodium as a coolant does leave the reactor in a more protected condition than water because sodium takes longer to boil away.

The key to the issue is the difference between the reactor's operating temperature and the boiling point of the coolant. In LMFBRs the difference is about 700 degrees Fahrenheit; in LWRs the operating temperatures and boiling points are about the same. Thus, LMFBRs provide a much greater safety margin in this area because they provide the reactor operators with more time to react to accident conditions involving a coolant leak.

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b. Similarly, the White Paper overlooks the fact that CRBR is designed with passive--no moving parts--guard vessels to assure that there will be no loss of coolant.

Without multiple reactor system failures, the sodium coolant in LMFBRs will not get into the containment area of the reactor building. It will be contained by the guard vessel since the system operates at close to atmospheric pressure. In comparison, water coolant will flash to steam when outside the reactor vessel and the radioactive steam is very difficult to control. Unlike the sodium coolant, the steam may flow into the containment building instead of remaining in the reactor's primary coolant system. The high pressure steam of an LWR is much more difficult to contain than the low pressure sodium of an LMFBR.

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c. Do these omissions detract from the credibility of the White Paper?

While the White Paper does identify the low pressure sodium heat transfer system as an LMFBR safety advantage, it does not provide any elaboration of this feature that would make it meaningful to a reader having only general familiarity with nuclear reactor concepts and operating principles. Moreover, it does not discuss in any way the inherent safety advantages of sodium coolant due to its high boiling point. In our opinion, a brief discussion of both of these items in the White Paper would have helped make it more balanced.

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5.a. Is the administration's concern over safety for the Clinch River project, which will be required to go through a complete licensing process, any different from their concern regarding the operation of Shippingport?

We were informed by spokesmen for the administration that there is no difference in their concern for the safety of Clinch River versus Shippingport. It is the administration's position that it intends to assure the public health and safety of all nuclear installations. We found no reason to question this position.

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b. What different circumstances surrounded the administration's decision to convert the reactor (at Shippingport) to a thorium fuel cycle?

According to DOE the different circumstances involved the licensing environment of Shippingport versus CRBR.

The Shippingport facility was subjected to an NRC licensing review that, while it did not involve public participation, was conducted under licensing regulations already established for LWRs. Accordingly, since Shippingport is an LWR, the licensing criteria and framework were already known. In comparison, the regulations for licensing the CRBR, or the larger breeder plant that is now being considered by the administration have yet to be determined.

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c. What has Shippingport contributed to our perceptions about safety that are applicable to the CRBR?

We do not believe that Shippingport has any direct safety implications for the CRBR.

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6. Does GAO regard as significant the administration's failure to acknowledge that essentially all of the issues mentioned in the White Paper were previously addressed in communications between the project and NRC staff?

Yes. In our opinion, the section of the report dealing with the subject--"Clinch River Breeder Reactor Safety," page VI-5--would have been more informative had it more accurately portrayed the licensing status and nature of the outstanding safety questions on CRBR.

For instance, as your question indicates, essentially all of the major outstanding licensing issues on the CRBR were previously addressed in communications between the project and NRC staff. While the administration has never suggested otherwise, the reader of the White Paper is left with the impression that the outstanding safety issues have never been confronted by CRBR project management. This is not true. Subsequent to the suspension of NRC's safety review in April 1977, CRBR work in designing and manufacturing equipment and components has continued in essentially all of the issue areas. However, NRC has not reviewed this continued work and does not know to what extent its views, recommendations, and safety criteria have been taken into consideration. In this context, the White Paper could have noted that NRC is of the opinion that "the (CRBR) design exhibits no unusual features or characteristics which cannot be modified within the present state of technology to conform to the NRC staff's requirements. In this sense, the issues left unresolved appear to be resolvable." It appears to us that this information puts the issue, as presented in the White Paper, in a somewhat more balanced perspective.

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7. The White Paper refers on page VI-5 to an NRC document dated November 9, 1978, which identified safety questions that had not been resolved. This document is entitled "NRC Staff Review of CRBRP--Summary of Outstanding Items." Are all these safety questions still unresolved and are the remaining unresolved questions considered to be solvable within reasonable economic limits?

None of the safety questions have been resolved to the satisfaction of NRC. CRBR project management addressed all 92 safety items identified in the November 9, 1978, document in a report provided to the NRC in March 1979. It is the position of the project management that the response identifies 19 items where additional information is needed by NRC, but where no basic disagreement exists between NRC and the project; 61 items in which the project agrees with NRC and identifies those submittals already made to NRC which demonstrate compliance with the requirements; and 12 items which require project/NRC interaction in order to achieve resolution. However, NRC has not concurred formally or informally with the March 1979 report or with the project's characterizations of the status of the 92 safety items contained in the report.

The NRC staff is of the opinion that the state of technology is such that CRBR design criteria can be met. As stated in the answer to Question 6, the NRC staff believes that the CRBR design "exhibits no unusual features or characteristics which cannot be subsequently modified within the present state of technology to conform to the NRC staff's requirements. In this sense, the issues left unresolved appear to be resolvable." However, without knowing exactly what must be modified to make the CRBR licenseable, we believe an attempt to reach a conclusion about the economic impact such modifications might have on the project would be premature.

NONPROLIFERATION POLICY

1.a. Hasn't the U.S. committed in INFCE (International Nuclear Fuel Cycle Evaluation) to permit national breeder programs to proceed?

Administration officials told us that the U.S. position on the development of national breeder programs in other countries is one of agnosticism. In this context, it was pointed out that INFCE is an evaluation of nuclear fuel cycle alternatives and is not a negotiating mechanism. Accordingly, no government will be bound by the results of the evaluation.

As a general policy the United States has acknowledged that for advanced nuclear states, breeder reactors may well constitute an important energy source in the 21st century. The United States has not attempted to discourage such states from pursuing R&D to maintain a future breeder option. According to the administration it would be inconsistent with its own larger breeder R&D effort. The United States has, however, argued that other countries should reassess the time scale on which breeders, and their associated facilities, including reprocessing facilities, need to be introduced and strive to incorporate proliferation resistance criteria into their breeder programs.

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b. Aren't we also prepared to accept continuation of reprocessing activities in all of those countries which currently have facilities such as France, Britain, and Japan?

U.S. policy on reprocessing activities abroad is that such activities should, in addition to incorporating maximum institutional and technical safeguards against proliferation risks, be confined to, and paced in accordance with, strict requirements for breeder and other advanced reactor R&D. According to administration spokesmen, the United States maintains the view that reprocessing for thermal recycle is economically unjustified at this time and poses significant proliferation risks due to substantially increased demand for transfers and storage of weapons-usable plutonium.

When the United States has been asked to approve requests for the retransfer of U.S.-origin fuel for reprocessing, our approach has been to review each case to ensure that the retransfer would not result in significant increases in the risk of proliferation and to determine whether: (a) a physical need exists, (b) the contract was entered into prior to the change in U.S. policy on reprocessing, and (c) the retransfer would further U.S. nonproliferation objectives. In all cases, the United States has retained control over disposition of resulting plutonium to ensure that any subsequent use is consistent with U.S. policy objectives.

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c. How is termination of CRBR consistent with this posture?

According to the administration the continuation of CRBR is inconsistent with its expressed nonproliferation policy because it points toward an early commercialization commitment which is not believed to be necessary. Further, the administration believes that continuing CRBR sacrifices the opportunity to explore breeder alternatives in a more flexible environment in light of the U.S. nonproliferation and energy requirements.

We discussed this issue on pages 7, 8, and 9 of our May 7 report on Clinch River and reached a different conclusion. In that report, we concluded that constructing the Clinch River facility will not hinder the administration's nonproliferation initiatives. Our basic rationale was that a failure to construct the facility would set the United States in a position of weakness by taking away the one aspect of the breeder program that could influence breeder-related decisions of foreign countries. We also pointed out that the CRBR does not represent an irrevocable commitment to the commercialization of LMFBR technology, but only an attempt to demonstrate that the technology is licenseable and workable.

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2.a. Would it be a good idea for the U.S. to explore "internationalizing" the CRBR effort as a carrot to other nations?

In answering this question we obtained the views of officials from the DOE, Arms Control and Disarmament Agency, industry organizations, and CRBR management. Their general reaction was that internationalizing the CRBR is not a very viable option. Generally, the reason was that other nations would probably not want to participate in the CRBR effort because of the uncertain status of the program. Also, according to many of those we contacted, the usual route of international cooperation and coordination in technical areas such as this is through the exchange of information. Based on our discussions, we have no reason to question the conclusions drawn by these people. However, we will consider this idea in more depth in our future work in the area of LMFBR technology development, which we plan to do over the next 1 to 2 years.

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b. Is there any facility available for alternative fuel cycle evaluations as flexible and of the scale of the CRBR?

It is generally agreed that the Fast Flux Test Facility (FFTF), scheduled for criticality in 1979, will provide the world's most advanced and versatile test reactor capability. It is specifically designed for testing and evaluating advanced and alternative fuels and material systems that may be used in foreseeable fuel cycle options. However, it is not of the same scale as the CRBR facility. FFTF is smaller than CRBR by a factor of about 2-1/2 times.

We do not believe, however, that it is beneficial to compare the two facilities as the question implies. The CRBR facility, unlike the FFTF, was not specifically designed for alternative fuel cycle testing. CRBR is designed to demonstrate that an LMFBR plant can be licensed and can operate reliably in a utility environment. While the CRBR does have the flexibility to test alternative fuel cycles, its intended purpose is to provide the industry with hard data on the operability and reliability of the LMFBR technology as a step toward larger commercial facilities if they are needed and desired. To the extent alternative fuel cycle experimentation is done in the CRBR its original objectives may be compromised to some degree. This would not be true with the FFTF facility.

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3. How far behind the French are we? (Phenix, Super Phenix), the United Kingdom? Soviet Union? (BN-350, BN-600) the Japanese? (Joyo)

It is difficult to estimate just how far the United States is behind any of these countries. The timing and pace of the U.S. LMFBR program is a function of commitment, determination, and industrial capability on the part of this country. Most experts we contacted agreed that if our objective was to catch up with other countries' breeder programs we could do so in a relatively short period of time.

A brief recap of the status of the French, United Kingdom's (UK), Soviet Union's, and Japanese programs follow:

French

The French program emphasizes the construction and operation of a series of LMFBRs of increasing size. The Phenix, an intermediate-size demonstration plant similar in size to CRBR, went into operation in 1973 and is still in operation. And, the Super Phenix, the world's first commercial-size LMFBR plant is expected to begin initial testing in 1983. It has been estimated that the United States is from 8 to 10 years behind the French in the area of large plant design and operation. However, it must be recognized that the emphasis of the U.S. program is different than the French in that this Nation places more emphasis on the development of a sound underlying base technology.

UK

The UK began an intensive LMFBR design and construction program in the mid-1950s. In 1974 a 250-MWe Prototype Fast Reactor (PFR) went into operation and has been operating since. Like the French Phenix facility, the PFR facility is the UK's counterpart to the CRBR. Further, they are now designing a commercial-size LMFBR plant to begin operation in 1986. We were unable to obtain any clear consensus on whether the UK's program is ahead of the U.S. program. While it is generally agreed that the UK's program is ahead in terms of its PFR facility, many people believe that this is offset by the stronger U.S. program technological base and industrial development capability.

Soviet Union

The Soviet Union has been operating a demonstration plant since 1972, the BN-350. Currently, it is constructing the BN-600 facility which is scheduled to go into operation sometime in 1979. The BN-600 is a 600-megawatt electric plant that represents the world's largest LMFBR plant to date. Further, they are now designing a commercial-size facility with a capacity of 1600 megawatts electric. It is widely recognized that the Soviet Union's program, along with the French program, are the most aggressive LMFBR development programs in the world. It has been estimated that the United States is about 5 to 8 years behind the Soviet Union's in the development of this energy option.

Japan

Japan has essentially copied the U.S. LMFBR program, in that its development focuses on broad technology development and component proof testing along with a progression of increasingly larger LMFBR plants. The Japanese LMFBR program began in the early 1960s. The small experimental Joyo reactor began operation in 1977 and a 300-megawatt electric prototype demonstration plant is under construction and expected to be operable in 1984. A commercial-size plant is also planned. There appears to be general agreement that if CRBR is built as originally planned, the United States and Japanese programs are proceeding on a comparable timetable.

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