"An Alternative LMFBR Program"*

by
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as revised
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Background

At the direction of President Carter, ERDA is initiating an intensive review of the Liquid Metal Fast Breeder Reactor (LMFBR) program in general, and the Clinch River Breeder Reactor (CRBR) project in particular. According to an ERDA announcement of the review of the LMFBR program:

The President's energy priorities, as reflected in the revision of ERDA's FY 1978 budget request, stress conservation and nearer-term supply technologies. These priorities suggest that past plans for expansion of the LMFBR program may no longer be viable. Furthermore, serious questions have been raised about the LMFBR technology and the structure of the current LMFBR program. The energy potential of this option must be weighed against the safety questions associated with the LMFBR and the dangers of nuclear proliferation from plutonium reprocessing needed by LMFBRs. The delays in the CRBR project and its currently projected costs make it necessary that a reexamination of the project be undertaken before any final decision on whether to proceed with construction. At the same time, we will reexamine the makeup and direction of the overall LMFBR program with or without this key project. The potential application in the U.S. and the role in the U.S. breeder program of foreign breeder technologies will also be reviewed.

* An earlier version of this paper under the same title was prepared and circulated on January 25, 1977.
The Option

This paper sets forth an alternative LMFBR program consistent with President Carter's campaign pledges to severely reduce our excessive emphasis on this project and convert it into a long-term possibly multinational effort (See Appendix A). Under this alternative program the commercial component of the present LMFBR program would be cancelled and commercialization of this technology postponed indefinitely; the breeder option would be preserved, however, as an alternative for the "post fossil fuel era" by continuing a basic R&D effort; but the R&D would be redirected toward breeder and near-breeder concepts that are intrinsically more proliferation resistant than the present plutonium based technologies and this effort would be at a much reduced funding level.

In its immediate effect, the CRBR demonstration plant is cancelled and the LMFBR priority, in terms of funding, is substantially reduced. In the near term, the program is focused on advanced design work, basic safety research in support facilities, and advanced fuels research in the fast Flux Test Facility (FFTF).

Rationale

The rationale for this option is based on the following considerations:

1. The risks of making massive investments in a plutonium-based energy technology and moving rapidly towards a U.S. and world commitments to a plutonium economy;

2. The present misplaced energy R&D priorities characterized by an excessive emphasis on commercialization of the LMFBR technology, neglect of energy conservation potential, and underfunding of alternative non-nuclear supply technologies;
3. The enormous cost overruns which the LMFBR program is experiencing;

4. Obsolete design of the CRBR -- a design that does not contain features that could considerably enhance the safety of the CRBR and the commercial viability of the LMFBR.

5. The inconsistency of the present LMFBR program structure, focused on commercialization, with ERDA policy to postpone a decision on commercialization for at least a decade until key issues related to safeguarding special nuclear material, breeder reactor safety, waste management and uranium availability are resolved; and

6. The lack of a clear economic incentive to continue the LMFBR program at the current pace.

Each of these issues is discussed separately below, followed by an analysis of the budget consideration in adopting this program alternative (beginning on page 16).

1. Dangers of the Plutonium Economy

President Carter is joined by a coalition of arms control experts, economists, environmentalists, civil libertarians, church groups and legislators in recognizing the dangers in moving rapidly toward a worldwide plutonium economy. The positions of this coalition reflect a growing consensus:

* Reprocessing and recycling of plutonium should not proceed unless there is sound reason to conclude that the world community can overcome effectively the associated risks of proliferation of nuclear weapons.

1/ See quotations in Appendices A and B.
* Avoidance of proliferation must take precedence over economic interests and the evidence indicates that the breeder program cannot pass the benefit-cost test.

* Controlling nuclear proliferation may become impossible if the nuclear industry here and abroad launches the next phase of nuclear power development -- the so-called plutonium economy including fuel reprocessing and civilian plutonium stockpiles.

* The U.S. cannot expect other nations to forego plutonium utilization if we act as though it is an indispensable component of our own national energy policy.

* A U.S. decision to make the breeder reactor a priority energy program would legitimize the argument of an *ipso facto* nuclear weapons state that it also needs the breeder and its plutonium nuclear fuel program and stockpile are peaceful.

A separate report, "Nuclear Weapons Proliferation - The State Threat and the Non-State Adversary" provides a more detailed analysis of the basis for the above conclusions. It also explains why it is of utmost importance and urgency to unequivocally reject the idea of reprocessing nuclear fuel for plutonium recovery in the foreseeable future either here or abroad.

An often repeated argument for proceeding with the plutonium

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economy is that the genie is out of the bottle and any country that wants a weapons option can build the necessary facilities dedicated to achieving that option. This argument fails to recognize that if reprocessing, and recovery and stockpiling of plutonium are permitted by non-weapons states, then without violating any of the international safeguards agreements and treaties, any non-weapons state could move to a point of being as little as hours away from having nuclear weapons, perhaps needing only to cast the plutonium and place it into the weapon. The non-weapons state in such an event would have all its options open. Like Israel, it could declare itself a non-weapons state, yet, at any time, it would be only moments away from having a weapons option. Under these conditions, the international safeguards regime serves nothing more than a cover for nascent weapons states, concealing the signs of critical changes taking place prior to the actual diversion.

Furthermore, once reprocessing large flows of recovered plutonium, and plutonium stockpiles become a worldwide reality, the shortest road to a weapons option is no longer the time-consuming and obvious construction of dedicated facilities. Instead, the preferred route would be through the civilian nuclear power program, through the peaceful atom.

Several proposals, the possibility of multinational ownership of fuel reprocessing facilities, "co-processing" of breeder fuel, and restricting breeders to weapons states have been suggested as a means to curb their proliferation potential. These concepts offer little, even if they could be shown to be practicable.

Multinational facilities would legitimize the argument of non-participating countries that their national plutonium facilities and stockpiles are peaceful. They would supply participating non-weapons
states with large amounts of usable plutonium in the form of fresh fuel. And they would provide opportunities for the clandestine diversion of plutonium, targets for expropriation, and the means of spreading reprocessing technology. Similar arguments apply to the concept of restricting breeders to weapons states. It is unrealistic to believe that separated plutonium can be restricted to nuclear weapons states in a world heavily dependent on plutonium fuel with reprocessing.

Co-processing of breeder fuel has been proposed by ERDA as an approach that "could potentially eliminate separated plutonium from the reprocessing and recycle scheme." A country with such a facility would need only to change the solvents used in the reprocessing operation, a trivial exercise in chemistry, to convert the facility to the production of pure plutonium. Furthermore, it is a simple chemical operation to separate the plutonium from the co-processed plutonium and uranium mixture. Thus a non-weapons state would still be only a matter of days away from having weapons usable material in hand.

It is essential that the U.S. breeder effort, if allowed to proceed, be restructured to pursue only breeder and near-breeder technologies that are more proliferation resistant. A minimum criterion for acceptability in this regard would be that the technology must be as proliferation resistant as existing light water reactors operating in the once-through fuel cycle mode, that is, without reprocessing, and with the additional constraint that no spent fuel storage would be permitted in non-weapons states. In other words, the development and commercial utilization of such technologies by a non-weapons state must leave that state months to years away from obtaining weapons usable material. Thus, the shortest route to a weapons option would still be the time-
consuming development of a dedicated facility.

2. **Misplaced Energy RD&D Priorities**

ERDA's proposed FY 1978 energy RD&D budget under the new Administration continues the Ford Administration's heavy emphasis on nuclear power development, at least pending promised reviews of the LMFBR program and ERDA's program for developing the nuclear fuel cycle. As demonstrated in a separate analysis of the Carter Administration's ERDA FY-1978 energy budget:

* Approximately 40-45% of ERDA's proposed RD&D budget is allocated to fission power development. Approximately one-half of this amount (20% to 25% of the total ERDA budget) is for one program - the LMFBR. In contrast only 21% is allocated to conservation, solar and geothermal combined.

* The Carter Administration has doubled the funding for energy conservation and restored the Ford Administration cuts in the funding requested by the conservation division within ERDA.

* While President Carter called in the campaign for a strong shift in energy R&D towards solar energy and conservation, the Carter Administration has given the solar program a mere cost of living increase over FY 1977 funding levels: proposed budget authority for FY 1978 is increased only 5% over FY 1977.

* The Ford Administration cut the R&D funding requested by the geothermal division by 29% (budget outlays). The Carter

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Administration restored none of it. The geothermal program funding is increased by 3.3% over FY 1977, not even a cost of living increase.

* ERDA is poised to launch a massive new program to subsidize the back end of the nuclear fuel cycle. Pending the outcome of a Carter Administration review of non-proliferation policy, funding in FY 1978 could be directed toward launching the plutonium economy in initiating a program to "demonstrate" plutonium reprocessing and plutonium recycle programs. Alternatively, if the new Administration decides to postpone plutonium recycle, these funds would be used principally for the management and long-term storage of used reactor fuel.

Under the Ford Administration budgetary constraints on ERDA were consistently resolved by proceeding with nuclear programs and cutting back on options to it. The Carter Administration shifted some funds (about 8% of that allocated to Energy RD&D Programs), from the LMFBR and fusion programs to previously underfunded non-nuclear technologies, principally energy conservation. Unless the breeder funding priority is substantially reduced, however, it is highly likely that future budgetary constraints will again be resolved in favor of nuclear programs.

The breeder program and nuclear fuel cycle and safeguards R&D each represent about 45% of the total nuclear fission R&D budget. Even if ERDA abandons the idea of launching the plutonium economy by a multi-billion dollar effort to "demonstrate" plutonium reprocessing and other plutonium recycle programs, massive federal funding undoubtedly will be required for alternative spent fuel management programs. Hence, if the breeder program is allowed to proceed as a restructured program in pursuit of more proliferation resistant technologies at
the same level of effort, the nuclear technologies will continue to dominate the energy RD&D budget and absorb a large fraction of future additional funding. On the other hand, as will be shown subsequently, by eliminating the commercial component of the LMFBR program and converting the program into a long-term possibly multinational effort, the program can be reduced to, and maintained at, a funding level roughly half the present effort.

3. LMFBR Cost Overruns

Initial cost estimates of the LMFBR program made in the mid-1960's were about $1.8 billion to $2.2 billion. The AEC and ERDA have already spent roughly $3 billion and government estimates of cost to completion are in the neighborhood of $8-$10 billion. Only a small fraction of this enormous overrun can be attributed to inflation. Estimated additional LMFBR program expenditures to achieve LMFBR program objectives have been increasing in recent years faster than cumulative expenditures to date, even when using constant dollars. As long as this trend continues, ERDA projections of additional program expenditures will substantially understate the true cost and the ultimate expenditure ceiling will remain unknown.

Significantly, the Fast Flux Test Facility (FFTF), an essential component of the LMFBR Program, was authorized in 1966 at $87.5 million. The FFTF is now 5 years behind schedule and additional delays are expected. The latest ERDA cost estimate is $647 million, up another

$107 million from last year. If one also includes additional FFTF support costs, last estimated by GAO at $6.7 million, the total cost of the FFTF program is $1.26 billion, over ten times the original cost estimate.

The second most significant component of the LMFBR Program is the Clinch River Breeder Reactor (CRBR), the first LMFBR demonstration plant if one overlooks Fermi-I. The first official estimate of its cost was about $400 million. In a 1972 Memorandum of Understanding its cost was estimated at $700 million, two-thirds coming from the AEC and with the AEC (now ERDA) assuming an open-ended risk (i.e., all the cost overruns). In March 1974, it was reported that CRBR project officials are "focusing on some major steps that they hope will hold the total cost of the plant under $1.0 billion." By September 1974, its operating schedule had slipped 4 years to mid-1973 and its cost increased to $1.736 billion, an increase of more than $1 billion. In March 1976 official ERDA cost estimate was $1.95 billion. This cost estimate was based on obtaining a Limited Work Authorization (LWA) in November 1976, and a Construction Permit in 1977. The Carter Administration has reduced the CRBR FY-1978 budget by $85 million in author-

5/ The Energy Daily, November 30, 1976. p. 4. The "support costs" were not included in the original FFTF cost estimate.

6/ Fermi-I, the first commercial LMFBR plant, experienced a partial core meltdown and has subsequently been shut down.


ity and $23 million in outlays. Thus, construction will not begin during FY-1978, and an optimistic February 1984 criticality date for CRBR has been pushed back to June 1984 at the earliest. Hence, it is clear that the CRBR cost will increase again. By ERDA estimates scheduling delays add about $11 to $15 million per month. In addition, if the CRBR site has to be moved in order to meet NRC regulations related to site suitability, by ERDA estimates this could delay the project on the order of 43 months and could cost up to $963 million. NRC estimates a 27 month delay at a substantially lower cost (up to $56 million).

4. The CRBR is an Obsolete Design

The CRBR demonstration plant was designed to utilize to the fullest extent possible the FFTF technology; thus the CRBR represents a simple 3:1 scale-up of this 10 to 15 year-old technology. About one-half of the CRBR systems are systems that one would want to modify. The present design does not incorporate important safety systems that are incorporated in foreign breeder demonstration plants, or are under investigation by ERDA at the Argonne National Laboratory. These include self-actuating shut down systems that operate on changes in reactor temperature or sodium coolant flow, and flywheels on the sodium coolant pumps to delay the initiation of fuel melting following loss of power to the pumps, and a core-catcher to reduce the consequences of a reactor meltdown accident.

5. Inconsistency of LMFBR with ERDA Policy

On December 31, 1975, the Administrator of ERDA issued a policy statement entitled "Administrator's Findings on the Liquid Metal Fast Breeder Reactor Proposed Final Environmental Statement." The overall

thrust of this policy statement was that the decision on whether to commercialize the LMFBR both can and will be made in 1986 and that ERDA's only commitment in the meanwhile is to an R&D effort aimed at gathering the information needed to make the 1986 decision. Since the Administrator's announcement there have been no LMFBR program changes designed to insulate the commercialization of the technology from the basic R&D needed to resolve certain key safety issues (see Appendix C).

In the six years prior to the Administrator's decision, the LMFBR demonstration plant program was designed to achieve "a competitive, self-sustaining industrial LMFBR capability." This demonstration effort was referred to as the "utility commitment phase." It was planned and implemented expressly to achieve commercialization of the breeder technology. As recently as May 1975, six months prior to the Administrator's finds, industry spokesmen were stating:

There are no residual questions as to the practical engineering feasibility of the LMFBR. The LMFBR is entering the near-commercial stage, and now is ready for the large-scale design, manufacturing, and operating experience which forms the base for commercial use.10/

While the nuclear industry recognizes that about one-half of the CRBR systems are obsolete, the majority of industry representatives with a vested interest in the LMFBR cling to the CRBR out of fear that postponing the demonstration plant would destroy the momentum of the

breeder program. As viewed by the industry last year,

The urgency for proceeding with the LMFBR arises from its ability to put a ceiling on cumulative uranium resource demand and accompanying ceilings on additional enrichment plants. Further, the combination of the LWR and the LMFBR provides the best economic system for long-term use of plutonium... This momentum, however, is no longer essential. The U.S., since the oil embargo, has had three years of zero energy growth. Hardest hit has been the nuclear industry. Cancellations and postponements are outstripping sales. Only seven nuclear units were sold in the U.S. in 1975. The three units ordered in 1976 are really not new business. 1976 seems almost certainly to be essentially a no-order year. No orders are anticipated before the latter part of 1977. ERDA projections of market penetration by nuclear plants have been reduced from 1,200 GWe in 2000 just two years ago to 380 GWe to

I think it would be a tragedy, really to slow it down any large amount. Let me point out what you destroy.

You destroy the momentum of the engineering skills in fast breeders, because these people, who have been working on these, now have learned how to design large liquid sodium systems and how to design breeders. That momentum will be lost, and the manufacturing skills that go into specialized manufacturing techniques will be lost. You will have to start all over again with the next machine.

Essentially, I feel it is going to cost you that and more if you lose this continuity that the Clinch River provides. So, for policy reasons, I would urge the Clinch River continued and continued at a fairly rapid schedule.

Id., p. 919
620 GWe (mid-case=510 GWe). A more realistic total is less than half this amount. The trend is continued downward revisions in nuclear growth projections.

The "momentum" to commercialize the LMFBR is not only inessential, but it is undesirable. The very existence of the commercialization momentum would make it impossible to ensure a subsequent unbiased review of the desirability of LMFBR commercialization. The commercialization momentum is an undesirable ingredient in a restructured LMFBR R&D effort designed to resolve engineering uncertainties without a commercial commitment to the LMFBR and a plutonium economy.

6. **LMFBR Economics**

There have been numerous cost-benefit studies of the LMFBR program. Most of the analyses by outside reviewers have been highly critical of the breeder program and the AEC/ERDA cost-benefit analyses. An evaluation of the major cost-benefit analyses applied to the LMFBR program has been prepared for the Joint Economic Committee by its staff. Based largely on reductions in demand for electricity


and projected nuclear growth, this study concludes that the breeder could be delayed. A point by point summary of this evaluation is presented as Appendix D.

7. Summary

As essential ingredient of U.S. non-proliferation policy should be to insure that new nuclear technologies (breeders and advanced converters) if developed, are at least as proliferation resistant as present day light water reactors operating without reprocessing and without spent fuel stockpiled in non-weapons states. In other words, the future breeder and advanced converter programs should focus on designs that tend to maximize the time it would take a non-weapons state to obtain weapon useable material from the fuel cycle. The present LMFBR concept does not meet this criterion and therefore the commercialization of this technology should be postponed indefinitely, i.e., treated as a last resort technology. Since it is now widely believed that the LMFBR program can be delayed at least a decade without economic penalty, the program can and should be delayed.

The proposed strategy is to postpone indefinitely the commercial component of the present program. The breeder program would be restructured as a basic R&D effort to pursue proliferation resistant breeder and near breeder alternatives. The sequential development strategy recommended for the LMFBR program by the President of RAND also would be adopted. The basis for this strategy is summarized in Appendix E. The near term implications of this strategy would be to complete and operate the FPTF before committing to any commercial demonstration effort. The LMFBR effort in effect would be recast as a low-priority program focused on alternative LMFBR design-work, safety

16/ In fact, when the LMFBR program was launched, no consideration was given to its proliferation implications.
research, and advanced fuel development in the FFTF. The current plans for going ahead with the costly Clinch River demonstration plant would be cancelled. By greatly reducing the overall costs of the program, funds will be freed for the accelerated development of solar, geothermal, fossil, fusion and conservation technologies, and the tremendous public and private investments which could foreclose the option of ever stopping the LMFBR will be avoided.

Such a postponement would provide a period during which several types of data which bear critically upon the desirability of the LMFBR program could be gathered and assessed. First, more accurate information on uranium availability and future energy demand could be obtained. Second, during the coming decade knowledge regarding the potential of solar, geothermal, and fusion energy should increase dramatically with appropriate funding. And, third, this grace period could also be used to answer critical health, safety and security questions raised by the LMFBR with far more certainty than now present.

The problems associated with the present reactor program strongly suggest that we are only perpetuating and compounding a bureaucratic blunder by pursuing the current LMFBR program. The alternative strategy presented here would provide an opportunity to correct that mistake -- before it is too late.

Budget Considerations

Pending the Carter Administration's intensive review of the LMFBR program in general, and the CRBR in particular, the FY-1978 budget outlays for the LMFBR program (line item) are $651 million; the budget authority is $656 million (see Table 1). These figures
### Table 1

**FY 1978 ERDA BUDGET TO CONGRESS**

**PROGRAM TOTAL**

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*Pending Review*

exclude any LMFBR funding hidden under "Nuclear Fuel Cycle and Safeguards R&D" and funds under "Program Support" that should be prorated among the energy technologies.

Pending review, fully 32% of the LMFBR budget outlays (23% in authority) are earmarked for the CRBR. If the remainder of the LMFBR program (FY-1978 budget outlays equally \$442.3 million) is reduced by 32% the overall LMFBR effort could be cut to \$300 million, or less than half the present level. This level is consistent with the budgets for energy conservation and solar, and represents a 22% budget reduction over the FY-1976 level.\(^{17}\)

To identify precisely the further budget reductions to achieve this level of effort would require a more detailed analysis of the budget. These detailed budget figures are unavailable outside of ERDA. It is possible, however, to set forth general guidelines governing further budget reduction:

* CRBR Demonstration Program activities should be eliminated.
* FFTF Program activities should be continued at existing funding levels. Construction of the FFTF should not be delayed by budget cuts.
* Commercial-size LMFBR (e.g., Prototype Large Breeder Reactor (PLBR) design work should be shifted to design work on proliferation resistant breeder and high gain advanced converter technologies.
* LMFBR basic safety R&D should be continued in support of \(^{17}\) In real dollars.
alternative breeder technologies; however, work primarily
directed toward meeting CRBR licensing requirements (e.g.,
preparation of CRBR PSAR) and other CRBR-related efforts
should be discontinued.

* Advanced fuel R&D should be continued as a low priority
effort.

* Basic safety R&D support facilities (e.g., PBF, TREAT, and
HFEF) should be supported. Other support facilities designed
for CRBR and PLBR component testing should be continued at a
substantially reduced, low priority level of effort in support
of alternative breeder designs.

Finally, in order to insulate LMFBR R&D from commercialization
efforts, no industry should be allowed to perform ERDA funded R&D
directly related to LMFBR or other breeder commercialization (e.g.,
preliminary P.BR design work) without agreeing that the company would
not attempt to market breeder concepts or material based on this
research unless and until ERDA or the Congress makes a determination
that the U.S. should commercialize the technology for widescale use.
Appendix A

Excerpts from President Carter's Speeches During the Campaign

"I would certainly not cut out atomic power altogether. We can't afford to give up that opportunity until later . . .

. . . use atomic energy only as a last resort with the strictest possible safety precautions."

Source: Governor Carter, replying to question in first Carter-Ford debate, September 24, 1976

"During the past few years, two-thirds of all federal research and development funds went for atomic power, primarily for the liquid metal fast breeder reactor (LMFBR). . . . our excess emphasis on this project should be severely reduced and converted to a long-term, possibly multinational effort."

*        *        *        *

"As one who is intimately familiar with the problems and potential of nuclear energy, I believe we must make every effort to keep that dependence to a minimum."

Source: Address by Governor Carter on Energy to the Washington Press Club July 11, 1975
"All of us must recognize that the widespread use of nuclear power brings many risks. Power reactors may malfunction and cause widespread radiological damage, unless stringent safety requirements are met. Radioactive wastes may be a menace to future generations and civilizations, unless they are effectively isolated within the biosphere forever. And terrorists or other criminals may steal plutonium and make weapons to threaten society or its political leaders with nuclear violence, unless strict security measures are developed and implemented to prevent nuclear theft.

"Beyond these dangers, there is the fearsome prospect that the spread of nuclear reactors will mean the spread of nuclear weapons to many nations. By 1990, the developing nations alone will produce enough plutonium in their reactors to build 3,000 Hiroshima-size bombs a year, and, by the year 2000 worldwide plutonium production may be over one million pounds a year -- the equivalent of 100,000 bombs a year -- about half of it outside the United States.

"The prospect of a nuclear future will be particularly alarming if a large number of nations develop their own national plutonium reprocessing facilities with the capacity to extract plutonium from the spent fuel. Even if such facilities are subject to inspection by the International Atomic Energy Agency, and even if the countries controlling them are parties to the Non-Proliferation Treaty, plutonium stockpiles can be converted to atomic weapons at a time of crisis, without fear of effective sanction by the international community.

Source: Address by Governor Carter on Nuclear Energy and World Order at the United Nations, May 13, 1976
"I will redirect our own energy research and development efforts to correct the disproportionate emphasis which we have placed on nuclear power at the expense of renewable energy technologies. Our emphasis on the breeder reactor must be converted into a long term, possible multinational effort."

Source: Remarks by Governor Carter, San Diego, California September 25, 1976

"So I think the amount of money we are presently spending for liquid metal fast breeder reactors should be drastically reduced."

Source: Public Citizen Forum, August 9, 1976

"I think we ought to minimize our effort in the LFMBR field."

Source: Interview on National Public Radio, July, 1976
A breeder reactor system would circulate within itself huge quantities of plutonium. We do not know if it would be possible to prevent the diversion of some of this material to weapons. At the very best, we would need to take extraordinary measures, perhaps through special installations for centralized use and control of plutonium.

But for the present, we are not obliged to live with large quantities of separated plutonium. The option to recycle spent fuel would not be permanently lost and it is relatively inexpensive to keep spent reactor fuel in temporary storage pending future developments. Before we take the plunge into a plutonium fuel economy, let us look very closely at the risks and our ability to control them.

Dr. Fred C. Ikle
Director, U.S. Arms Control and Disarmament Agency

Speech before Conference on
"Nuclear Energy and World Order"
United Nations, May 13, 1976
Although our discussion of the once-through and thorium alternatives for fission power is quite preliminary, they appear at this stage to be sufficiently attractive from a security point of view to warrant that the present worldwide plans for the future of fission power be thoroughly reexamined before irreversible commitments are made to the plutonium economy. We must not stumble unwittingly into the plutonium economy.

We recommend that, until all nations have assessed more clearly several energy options, plutonium should not be separated from spent fuel from civilian reactors anywhere in the world. It is after all the long-term future of fission power that is at issue. It would be foolhardy indeed to foreclose possible attractive future paths through precipitate decisions on reprocessing and recycle.

[Emphasis supplied.]

Energy strategy and environment

There are substantial environmental objections to a nuclear power programme on the scale envisaged in official projections (479-483).

It appears possible that an alternative strategy could be devised that would avoid the future need for a large nuclear programme based on fast reactors (492-497).

Nuclear power and public policy

We are sufficiently persuaded by the dangers of a plutonium economy that we regard this as a central issue in the debate over the future of nuclear power. We believe that we should not rely for something as basic as energy on a process that produces such hazardous substances as plutonium unless we are convinced that there is no reasonably certain economic alternative. (186).

The dangers of the creation of plutonium in large quantities in conditions of increasing world unrest are genuine and serious. We should not rely for energy supply on a process that produces such a hazardous substance as plutonium unless there is no reasonable alternative (506, 507).

The abandonment of nuclear fission power would, however, be neither wise nor justified (508). But a major commitment to fission power and a plutonium economy should be postponed as long as possible (511).

There should be increased support for the development of other energy sources including energy conservation, combined heat and power systems and fusion power (513).

Source: Royal Commission on Environmental Pollution, Chairman: Sir Brian Flowers, Sixth Report, Nuclear Power and the Environment, September 1976.
Now, therefore, be it resolved:

5) That the Governing Board of the National Council of Churches urges the government of the United States to declare a moratorium on the development of a plutonium economy so that the people of the United States can assess the pros and cons of the issues, said moratorium to be defined as follows:

A moratorium on the commercial processing and use of plutonium as an energy source, and on the building of a demonstration plutonium breeder reactor, pending further study of the theological, economic, socio/political and technical issues involved.

"The Plutonium Economy"
Resolution adopted by the Governing Board of the National Council of Churches, March 1976
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Under the weight of "new information, new dangers, new concerns," Percy has come to the "reluctant conclusion" that now is the time to "stop, look and listen" to anti-nuclear voices. He already has advocated moving "a large chunk" of funds earmarked for the fast breeder program -- perhaps as much as two-thirds of the current $650 million budget -- to other programs such as conservation and solar. And he indicates that others in Congress have smelled blood too: "The breeder is going to have rougher sledding than it had before." He does not deny that nuclear energy is "always going to be an important part of our energy picture," at least for the next decades. "But to see it as a panacea, bury it in money -- especially when it won't deliver a net increase in energy until after 2000" -- this, he believes, is unconscionable.

June 17, 1976

Dr. Robert C. Seamans, Jr.
Administrator
U.S. Energy Research & Development Administration
Washington, D.C. 20545

Dear Dr. Seamans:

On December 31, 1975, you issued a policy statement entitled "Administrator's Findings on the Liquid Metal Fast Breeder Reactor Proposed Final Environmental Statement." The subject of this policy statement -- the LMFBR program -- is of concern to all Americans since it is the most expensive and controversial of all federal energy development programs. Among the conclusions contained in this policy statement are the following:

- ERDA has an obligation under the National Environmental Policy Act (NEPA) to make an independent determination regarding the desirability of commercially deploying fast breeder reactors prior to any decision to proceed with such deployment. However, insufficient information exists today to make this independent determination, and most likely the needed information will not be available until about 1986.

- Between now and 1986 ERDA will continue with the LMFBR program. However, such continuation is not inconsistent with ERDA making a meaningful decision on LMFBR commercialization in 1986 because (i) there will be no "irreversible" industrial commitment to the LMFBR by 1986, and (ii) the LMFBR program will not "inevitability" short-change the development of other energy options.
ERDA will prepare "at least one" additional programmatic environmental impact statement prior to any future ERDA decision on the commercialization of LMFBR technology. Current plans call for such a statement in 1986.

The overall thrust of this policy statement is that the decision on whether to commercialize the LMFBR both can and will be made in 1986 and that ERDA's only commitment in the meanwhile is to an R&D effort aimed at gathering the information needed to make the 1986 decision.

We have examined these conclusions and believe that some very serious inconsistencies and other difficulties are presented.

Initially, the proposition that our country can spend many billions of dollars between now and 1986 developing the LMFBR without prejudging the ultimate decision on commercial application lacks plausibility, for several reasons. This precise question was addressed by the U.S. Court of Appeals in the decision which directed the AEC to apply NEPA to the LMFBR program.*/ The Court's answer was very clear:

"Modern technological advances typically stem from massive investments in research and development, as is the case here. Technological advances are therefore capital investments and, as such, once brought to a stage of commercial feasibility the investment in their development acts to compel their application. Once there has been, in the terms of NEPA, 'an irretrievable commitment of resources' in the technology development stage, the balance of environmental costs and economic and other benefits shifts in favor of ultimate application of the technology."

**

"[B]ecause of the long lead times necessary for development of new commercially

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Scientists' Institute for Public Information v. AEC, 481 F.2d 1079 (D.C. Cir. 1973).
feasible technologies for production of electrical energy, the decisions our society makes today as to the direction of research and development will determine what technologies are available 10, 20, or 30 years hence when we must apply some new means of producing electrical energy or face the alternative of energy rationing, through higher prices or otherwise. The manner in which we divide our limited research and development dollars today among various promising technologies in effect determines which technologies will be available.

For the reasons indicated by the Court of Appeals, achieving a practical separation of an expensive R&D program from the push to commercialize the technology would be an extremely difficult goal under the best of circumstances. This problem is greatly exacerbated in the case of the LMFBR because the LMFBR program has been specifically designed and carried out to blur over and eliminate the distinction between R&D and commercialization -- to ensure a momentum that would carry the program easily from the former stage to the latter. Thus, in 1968 the original LMFBR Program Plan stated that the objective of the program is "to assure maximum development and use of a competitive, self-sustaining industrial LMFBR capability."* Similarly, in 1971 the Joint Committee on Atomic Energy described the LMFBR program as follows:

"The purpose of this development program is not simply to show that we can build and operate a Liquid Metal Fast Breeder Reactor. When that has been accomplished, we must at the same time have established a viable, competitive LMFBR industry which is ready and capable of designing, constructing, and operating large (1000 MWe) LMFBR's." H.R. Rep. No. 92-325, 92d Cong., 1st Sess. 25-26 (1971).

In a major speech on the LMFBR the Director of the AEC's Division of Reactor Development and Technology stated that the program had as its objective:**

/*/ AEC, LMFBR Program Plan (1969; WASH-1101), at 1-3.

"... the establishment of the breeder reactor system on a broad technical and engineering basis with sufficiently comprehensive industry involvement to assure a strong and competitive industrial capability in the early 1980's."

With respect to the LMFBR demonstration plant program he stated:*/

"Building demonstration plants is essential to developing the needed industrial participation as a prerequisite for an adequate industrial base and to establishing the conditions for meaningful industrial competition. Moreover, they are the means by which plant types gain acceptance for broader use in utility networks."

* * *

"As was shown so convincingly by the introduction of light water reactors into the market, the breeder demonstration plant program, along with the related industrial engineering efforts, will serve as the key to effecting the transition of the fast breeder program from the technology development stage to the point of large-scale commercial utilization."

This same objective of using the LMFBR program, and particularly the demonstration plant aspects, as the means of developing a competitive, self-sustaining industrial commitment to the LMFBR was reemphasized when the AEC invited proposals looking towards arrangements for the development and operation of an LMFBR demonstration plant**/ and also in a report to the AEC in March, 1972 (WASH-1201) by the Joint Senior Utility Steering Committee and Senior Utility Technical Advisory Panel.***/

*/* Ibid., p. 1, 7-67.


***/* WASH-1201, op. cit.
It is thus clear that during the years prior to your issuance of the Administrator's Findings six months ago, the LMFBR program was planned and implemented expressly to achieve commercialization of breeder reactor technology. Given this fact and the considerations outlined by the Court of Appeals, one would have expected your pledge to separate LMFBR R&D from commercialization to be accompanied by a series of far-reaching changes in the substance of the LMFBR R&D program itself. Yet the fact is that the LMFBR program, which was designed to achieve a "competitive, self-sustaining, industrial LMFBR capability," has changed hardly at all as a result of your statement of last December. We know of no special changes or precautions taken by ERDA for the purpose of ensuring a subsequent unbiased, timely review of the desirability of LMFBR commercialization.

Equally disturbing, we have information suggesting that ERDA's actions are encouraging potential LMFBR vendors to commit now to offer LMFBR's for sale in the future and, indeed, to offer them for sale substantially before 1986. In negotiations with the three vendors to design the Prototype Large Breeder Reactor (PLBR), the proposed commercial-sized follow-on to the breeder demonstration plant planned for Clinch River, Tennessee, ERDA has apparently obtained agreements from the three companies that each would be in a position by the end of the design period (1978) to make a proposal to a utility or other group to build such an LMFBR. In other words, our information is that ERDA has required of the three vendors a statement of intention on their part that they will be in a position where they could sell a large LMFBR plant to utilities in 1978.

ERDA's plans call for selection of a design of the PLBR in 1978 for operation by 1983. If commercialization is recommended in 1986, then the first commercial plant would be expected by ERDA to be on stream in 1993.*/ This schedule would be unworkable unless there were a substantial, essentially irreversible, vendor and utility commitment to the program at the time of the proposed ERDA decision in 1986.

*/ These dates are reflected in ERDA's "reference plan," the plan adopted in your December 31, 1975, statement. See ERDA, Final Environmental Statement for the LMFBR Program (1975; ERDA-1535), p. I-5, 6.
Moreover, we have been informed that Westinghouse Electric is going to begin trying to sell commercial-size LMFBR's to utilities after 1978 and hopes to achieve as many as 10 starts per year before 1986. When asked about this, one ERDA official responded, "ERDA has no control over commercialization. That is a matter between the utilities, manufacturers and the Nuclear Regulatory Commission." If this is the case, if ERDA has no control over commercialization, what meaning should we attribute to your statement that "ERDA's decision on commercialization must be made before any commitment to widespread deployment becomes irreversible"?

On the question of alternatives to the LMFBR, we believe the conclusion is inescapable that the mammoth size and large cost overruns of the LMFBR program are restricting the funding available to other energy options. By the time they reached Congress, ERDA's FY 1977 division requests for funding for energy conservation and for solar and geothermal energy had been cut back 54%, 50% and 41% respectively. Yet the request of the LMFBR program had been cut back only 7%. The funding allocated by ERDA to the LMFBR program (29% of the FY 1977 total for energy R&D) was vastly greater than the combined allocations to conservation, solar and geothermal sources (13%) and almost as large as the total allocated to all non-nuclear technologies including fossil, solar, geothermal and conservation technologies (35%).

Finally, ERDA should recognize that it has obligations under the National Environmental Policy Act to revise the impact statement for the LMFBR program on a regular basis as new developments occur and new information becomes available. One basis for the Court's holding that the original statement was required was that the LMFBR program comes before Congress each year as a "proposal for legislation" in the form of requests for authorizations and appropriations (Slip Op. 14). NEPA requires that the statement "accompany" these legislative proposals each year, and it is imperative in order that the public and the Congress be adequately informed that the statement be kept up-to-date. The Court itself recognized the need for periodic revisions of statements of this type (Slip Op. 36) and also set out cogently the reasons why not redoing the statement again until 1986 would violate NEPA:

"[B]y the time commercial feasibility of the technology is conclusively demonstrated, and the effects of application of the technology
certain, the purposes of NEPA will already have been thwarted. Substantial investments will have been made in development of the technology and options will have been precluded without consideration of environmental factors. Any statement prepared at such a late date will no doubt be thorough, detailed and accurate, but it will be of little help in ensuring that decisions reflect environmental concerns."

For all these reasons, we believe that the strategy for carrying out and reviewing the LMFBR program described in your December 31, 1975, statement must be reconsidered. That strategy fails to take into account a range of practical considerations regarding the design, size and momentum of the LMFBR program, and it also overlooks certain legal conclusions reached by the Court of Appeals in the Scientists' Institute case.

We would welcome the opportunity to discuss further with you the matters raised here.

Sincerely,

J.G. Speth

Thomas B. Cochran
APPENDIX D

POINT-BY-POINT SUMMARY

1. All of the major cost-benefit studies of the liquid metal fast breeder reactor (LMFBR) are incomplete, because they ignore the possibility that substantial costs in the form of long-lived radioactive wastes and their consequences will be transferred to future generations. The nuclear waste question pushes cost-benefit analysis beyond its capacity. A new analytical method may be required.

2. It may be very misleading to jump to conclusions of impending uranium shortages on the basis that uranium's reserve-production ratio is declining. In 1938, oil's reserve-production ratio was about 12. It would have been a serious error, however, to argue that the United States would run out of oil in 12 years unless something drastic was done. Although oil production has increased at 7.5 percent per year, oil's 1974 reserve-production ratio was 18. To argue similarly about uranium in 1976 probably is just as wrong.

3. Major increases in uranium reserve estimates over the past few years emphasize the uncertainties surrounding this resource base.

4. Because uranium reserves are expensive to prove and because uranium inventories are expensive to obtain and hold, proven reserves and inventories will tend to be low relative to other materials.

5. Uranium reserves also are low, because, until recently, uranium prices were declining. Incentives for exploration and development, therefore, have been weak.

6. The uranium resource analyses exclude consideration of major determinants of future uranium resources. They are structured in such a way as to impart a pessimistic bias to uranium supply projections.

7. Projected growth rates of electricity demand are a key to the decision on when to proceed with the breeder program. It appears that electricity growth rates beyond 1980 may be closer to 3 percent per year than to the historical growth rate of 7 percent. With a 2 percent growth rate, electricity consumption will be only 3.3 trillion kilowatthours in the year 2000, compared to projections of as high as 6.1 trillion in the major breeder cost-benefit studies. Thus the breeder could be delayed.

8. The major reason for slower projected power demand growth in the future is that the era of declining electricity prices seems to be over. The reasons for the end of declining electricity prices include (1) the end of scale economies for power generation, (2) the intensity of environmental concern and the internalization of some of the external costs of power production, and (3) the recent rapid increases in fossil fuel costs and in the capital costs of light-water reactor plants.

9. The capital cost differential between light-water and breeder reactors is a key to the breeder decision. Everyone agrees that the breeder's capital cost will be much higher than that of light-water reactors, but no one is sure how much higher it will be. If the differential is greater than $125 per kilowatt, the LMFBR's electricity will cost more than light-water reactor electricity.

Source: "The Fast Breeder Reactor Decision: An Analysis of Limits and The Limits of Analysis," A Study prepared for the use of the Joint Economic Committee, April 19, 1976
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10. Many analyses assume that LMFBR capital costs will decline with experience (i.e., "learning"). There is not much reason to believe there will be any decline, however. Light-water reactor construction on the contrary has experienced persistently increasing cost and has not displayed a learning-curve pattern. There is not much reason to believe that the breeder will fare better in this regard.

11. Most economists agree that intertemporal efficiency comparisons require the discounting of future costs and benefits, but they do not agree on what the particular value of the discount rate should be. Because the study by Staufer et al. uses a discount rate for the breeder's benefits substantially less than the 10-percent rate used in the other studies, it finds that the benefits of breeder development are quite high.

12. A problem with all of the breeder cost-benefit studies except that by Macne involves their specification of the future alternatives. The Macne study reviews two scenarios of the future—one with a certain date for breeder commercialization and one with various possible commercialization dates with probabilities attached. The other studies analyze only one future that assumes certain breeder commercialization as of a certain date. If breeder commercialization has benefits, all of the studies that analyze one future with certain breeder commercialization will find that the earliest breeder commercialization date will yield the greatest benefits. Because of this characteristic, these studies shed no light on the crucial issue of the timing of the breeder's development.

13. If cost-benefit analysis is to be applied effectively to the breeder development decision, alternative program timing strategies must be analyzed. Indeed, it can be argued that an assessment of such broadly defined alternative program strategies is the most important role for cost-benefit analysis to serve.
APPENDIX E

III. GUIDES FOR FUTURE POLICY

This section seeks to describe a strategy for decision rather than prescribe a specific course of action. The major features of a sequential development strategy are outlined first. Next, some of the impediments to such a policy are considered. Finally, techniques that may aid in implementing a sequential strategy are discussed.

It can be postulated that the purpose of a federal demonstration project encompassing great uncertainty in many dimensions is to reduce that uncertainty through the generation of validated information. The success of demonstration should therefore be judged by its efficiency in doing this job — reducing the uncertainty — and not by whether the technology is ultimately disseminated.

The uncertainties relate to several dimensions of this project — technology, costs, demands, reliability, safety, licensability, etc. A current Rand study of federal demonstration projects suggests that if the technological uncertainties are not well in hand, the ability of a demonstration to reduce the other dimensions of uncertainty is likely to be compromised. The first task, therefore, is to prove out the technology before proceeding to the next phases. Though I do not claim specific technical expertise on the LMFBR, the evidence seems to indicate that this first task has not yet been completed.

ERDA is conducting major studies to reduce many of the uncertainties. For example, over the next five years, the Natural Uranium Resources Evaluation Program should substantially increase our knowledge of domestic uranium availability. Even without

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1/ Source: Letter to Robert C. Seamans, Jr. from Donald B. Rice, Rand Corporation, Reprinted in the Final Environmental Statement of Liquid Metal Fast Breeder Reactor Program, ERDA-1535, Volume I.
special studies, new information is continuously becoming available that alters
the analysis and outcomes of the LMFBR: "The principal difference between
this cost-benefit study and previous cost-benefit studies is that the basic input
data have appreciably changed... Because of this, a new study was required for
this Environmental Impact Statement." [11.2-1]

Rand studies on technologically advanced systems have shown that austere-developed
technical feasibility prototypes are highly desirable both for components and for the
entire system before significant work is done to verify the other dimensions of the
system. The purpose of austerity is to force developers to use as much off-the-shelf technology as possible, to pursue new designs only where necessary, and to
infuse the project with greater creativity and more astute engineering.

Many of the European breeder development programs have proceeded in an incremental,
step-like fashion. The French have resisted commitment to a new phase until the
reactor of the preceding phase was operating successfully. In Germany, the 20 mW
sodium-cooled thermal reactor at Karlsruhe is being modified for operation as a fast
reactor. The Soviet Union reworked a 100 kWt (kilowatts thermal) mercury-cooled
plutonium reactor into a sodium-cooled plutonium reactor of 5 mWt power. This
reactor was later modified for operation at 10 mWt. By changing as few things as
possible at each new step, the uncertainties associated with each advance are
reduced. Each specific design may not be optimal, but it works, and the sequence
can lead to an optimal system design that works.

An essential feature of a sequential strategy is the learning that goes on between
phases. Incremental design reduces the amount of testing and learning that must
be done at each step. But it is vital that the test and evaluation phase not be
ignored. Once again, this takes time; in weapons developments, the costs of not
taking this time is measured in billions of dollars and reductions in effective force
size. When time is not critical, as in the LMFBR case, it is a cheap commodity;
and there have been very few instances where a rush to completion can be justified
after the fact. For that matter, there is little hard evidence to support the assumption
that incremental, sequential development is slower, in the end, than compressed,
concurrent development. It is at least as safe to conclude otherwise.

To summarize, my recommendations for a sequential development strategy include:
Austere development; incremental design; and time to test. Faced with such a large
degree of uncertainty, the prudent decisionmaker will (a) elect not to make decisions
that can't be wisely made now (commitment to the currently proposed full develop-

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1Robert L. Perry, et al., System Acquistion Strategies, R-733-PR/ARPA,
The Rand Corporation, June 1971; Burton H. Klein, et al., Military Research and
Development Policies, R-333, The Rand Corporation, December 1958; L. L. Johnson,
The Century Series Fighters: A Study in Research and Development, RM-2549-PR,

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ment program), (b) make today only the decisions that must be made today (for example, key components of CRBR), and (c) plan for the resolution of uncertainty over time (uranium supply, electricity demand, capital costs, R&D costs, etc.). To put it another way, a program that requires a minimum of 12 years to complete is simply beyond human ability to preplan with such confidence that one would want to commit to all of it.

One final point about this strategy: if everything goes well as proponents claim it will, if all the uncertain parameters turn out as estimated in the PFES, and if all the technology is as well in hand as proponents contend, this strategy will result, with very high confidence, in a working, safe and economical breeder only a few years beyond 1987. If the PFES scenario is adopted and proves faulty in any major respect, the least unfavorable result would be significant schedule slippage and cost growth.

Why is such a strategy so difficult to adopt for large, U.S. government programs? Project proponents don't like a sequential process. It implies smaller budgets stretched out over time. It appears to complicate their task by comparison with the illusory alternative of commitment to a fully preplanned course. The project can be perceived as easier to kill if things do not turn out too well -- or even if they do -- because there are no large economic or political consequences linked to cancellation.

Project opponents don't like this kind of low-profile sequential decisionmaking, either. They view it as the camel's nose under the tent. The program can be perceived as hard to kill in the early stages because the major production decision may be years away and no important resource commitments will be up for review until then. The project can develop a constituency and momentum over time that will later roll over its critics.

Politicians may have other reasons for disliking the sequential approach. They may feel short on the expertise needed to evaluate program decisions year after year. Multi-billion dollar decisions are political decisions with high transactions costs to those involved.

Thus, many pressures converge to force a major program review into a take-it or leave-it framework.

Despite the difficulties in running a sequential development program, I believe that ERDA should implement such a strategy. The present situation has grown out of past decisions, promises, and habits that will be hard to change. A shift in direction at this point, however, can be viewed as the result of a frank appraisal of new information and analyses. A stance of openness before the Congress and the public will certainly help to gain their confidence and trust and, perhaps, their grand of authority to manage the program. Further, there is no need to sell the LMFBR now as a
Billion-dollar program. Rather it can be straightforwardly described as a step
toward reducing uncertainty and averting risk for the future. This would require
a retrenchment of goals and a slimming down of tasks, but that may be a rational
response at the present time.

It must be openly acknowledged that much uncertainty exists in pursuing any new
technology -- especially one, like LMFBR, that depends on world-wide events
beyond the control of the project. A detailed future cannot and should not be
promised; there is always the possibility that the resources spent in advancing
LMFBR technology may not have the desired payoff. However, such efforts can
be structured to enhance the probability of success and to reduce the cost of
failure.

ERDA is of course now more than nuclear. A relative reallocation of resources
within the agency, as implied by recommendations to scale down and stretch out
the LMFBR, could enhance internal competition and foster more realism in estimates
generated by intramural reviews and critiques. It should also be noted that a
non-sequential process (which includes the option of cancellation) formally eliminates
the possibility of learning, increases uncertainty by straight-jacketing the future,
and increases the probability that costs (whether social or project) will be greater
than necessary. That is, a truly sequential approach could turn out to cost less
and take little, if any, additional time to attain the objective of a reliable, safe,
and economical breeder system.

ERDA stands astride many technologies and many possible changes. Its actions today
can have a significant impact on the future. Winning approval to carry out an
LMFBR project as currently structured could be a Pyrrhic victory. A defeat could
carry over to broader issues. A sequential strategy, honestly taken, periodically
and critically appraised, with the goal of reducing uncertainty and generating
validated information, can perhaps establish a course between these two equally
undesirable outcomes.

Sincerely,

Donald B. Rice
President

DB:ry

cc: The Honorable Robert W. Fri,
Deputy Administrator, ERDA