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STATEMENT OF

DR. THOMAS B. COCHRAN

BEFORE THE

JOINT ECONOMIC COMMITTEE

Breeder Reactor Hearings
May 8, 1975

Mr.Chairman and members of the Committee, thank you for this invitation to testify at these important hearings on the breeder reactor program. My name is Thomas B. Cochran, I am a staff scientist at Natural Resources Defense Council (NRDC), a non-profit environmental law firm with offices in Washington, D. C., New York, and Palo Alto. Prior to joining NRDC in 1973, I was a Senior Research Associate at Resources for the Future (RFF) here in Washington, where

73
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I wrote The Liquid Metal Fast Breeder Reactor: An Environmental and Economic Critique. Since 1971 I have been engaged full time following developments in the civilian nuclear power industry, concentrating principally on the Federal government's Liquid Metal Fast Breeder Reactor (LMFBR) program.

Since 1967, the LMFBR program has been the nation's highest priority reactor development program and since 1971 it has been accorded the highest priority among all the Federal government's energy research and development efforts.

The LMFBR's dominance of the energy research and development scene stands out clearly in recent budget estimates. During the coming fiscal year the new Energy Research and Development Administration (ERDA) plans to spend roughly one-third of its budget for energy R&D on this single reactor program, more than the combined allocations for fossil energy development, solar energy development, geothermal energy development, advanced energy research and energy conservation.

The total cost of developing the LMFBR is now estimated to be $10 billion, and this estimate, made by proponents of the program, must be judged as conservative. The true cost will probably be more nearly twice this amount. Already the

LMFBR program has experienced tremendous cost overruns. Two years ago total program costs were put at less than half of today's estimate. The principal test facility of the program, the Fast Flux Test Facility (FFTF) was originally planned to cost $87 million, but the latest estimate is over $1 billion, more than a ten-fold increase. Congress was told in 1973 that the proposed Clinch River Breeder Reactor Plant (CRBR), the first LMFBR demonstration plant if one overlooks Fermi-I, would cost $700 million. Today, the estimate is over $1.7 billion. As shown in the accompanying figure, the CRBR has a cost doubling time of one year. The Sodium Pump Test Facility, when it was authorized in 1966 was estimated to cost $6.8 million. The total cost is now estimated to be $57.5 million.[1/] There is no sound reason to believe these trends will not continue.

And it is not just the overruns. There are still hidden costs in the program. Recognizing that the next generation of plants following the CRBR will not be commercially competitive, ERDA has recently restructured the LMFBR program. All but one of the demonstration plants have been eliminated. These have been replaced by a Plant Component Test Facility to be followed by a commercial-size prototype called Near-Commercial Breeder Reactor (NCBR). What ERDA does not

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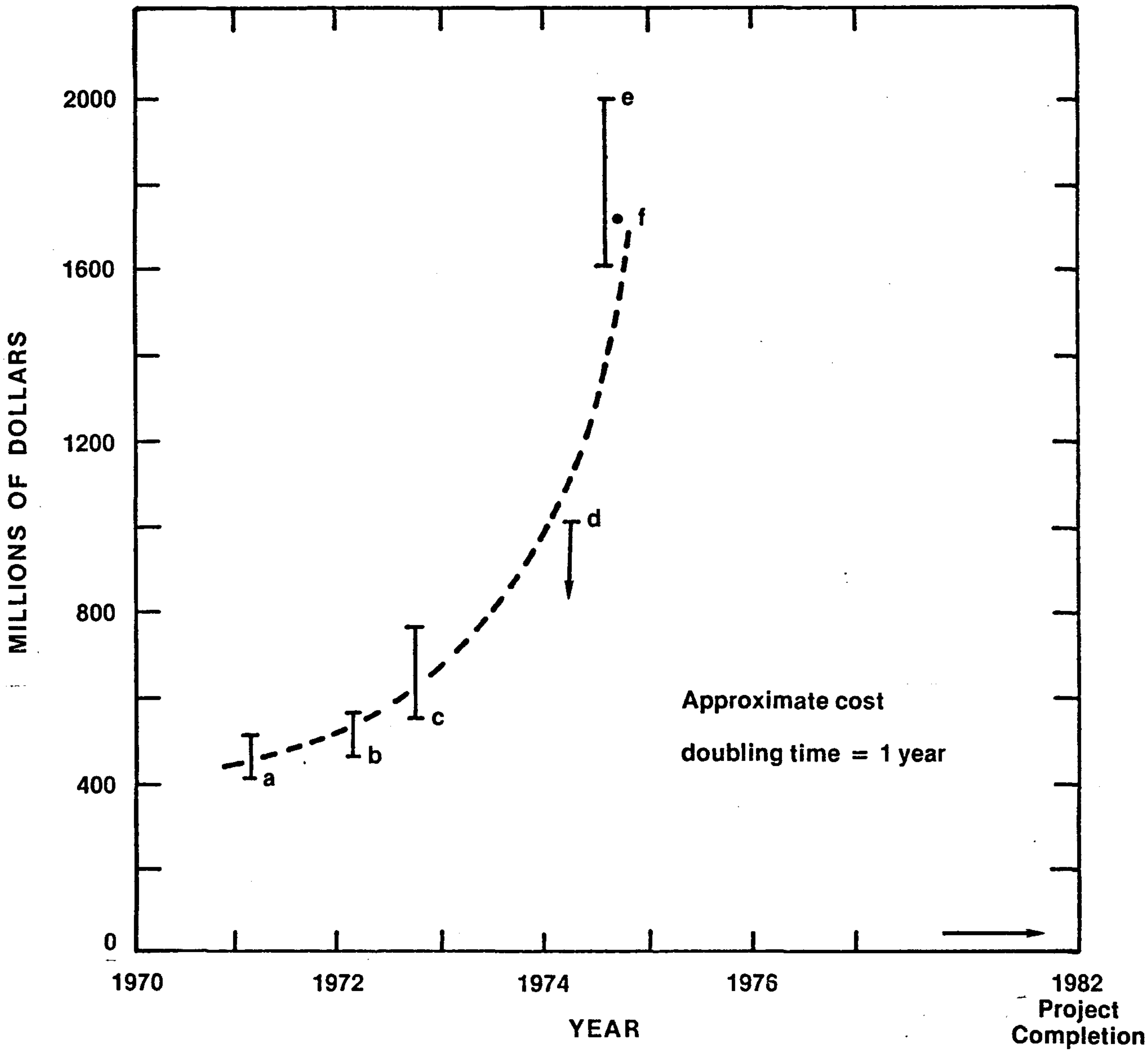
1/ Comptroller General of the United States, "The Liquid Metal Fast Breeder Reactor Program--Past, Present, And Future," Report to the Congress, ERDA. RED-75-352. April 28, 1975.

FIGURE 1

BREEDER REACTOR (COST) DOUBLING TIME



AEC Estimates of the Range in the Cost of the Clinch River Breeder Reactor.

Source: (a) JCAE Hearings, AEC Authorizing Legislation - FY 1972, p. 702.
(b) JCAE Hearings, AEC Authorizing Legislation - FY 1973, pp.1156-1159.
(c) JCAE Hearings, LMFBR Demonstration Plant, Hearings, p.44.
(d) Nucleonics Week, 15, March 21, 1974, p.1.
(e) Weekly Energy Report, 30, July 29, 1974, p.1.
(f) Weekly Energy Report, 38, September 23, 1974, p.6.

publicize is that it has earmarked only $300 million for the government's share of the NCBR. Yet a subsidy of at least one billion dollars will be required. Can we expect the utilities to absorb this loss? Experience suggests that we cannot. The federal government will be the major source of funding for the project, just as it has to fund the CRBR.

The fundamental question now before the Congress and ERDA is whether the breeder program deserves priority attention and great commitment of present and future resources. In my judgment it does not -- not only because of the environmental and safety concerns, but on the basis of economic considerations alone.

In my view the present LMFBR program with its high priority cannot be economically justified at this time. The basis for this view is contained in Bypassing the Breeder: A Report on Misplaced Federal Energy Priorities and reviews of cost-benefit analyses performed by other organizations. Bypassing the Breeder was prepared just over a month ago by Mr. J. Gustave Speth, Dr. Arthur R. Tamplin, both on the NRDC staff, and myself. Mr. Chairman, with your permission, I would like to submit this report and the accompanying Appendix for the record and then take this opportunity to review the economic issues detailed in this report.

The breeder economic issue is an issue of timing. When will the higher fuel cost of today's reactors offset the higher capital cost of the breeder? In addressing the LMFBR timing issue it is important to understand that the issue has nothing to do with blackouts or brownouts or the exhaustion of uranium fuel for the current generation of nuclear reactors. The breeder may ultimately promise to be cheaper because of its very low uranium cost per unit energy. But fuel costs represent only a small fraction of the cost of electricity from nuclear reactors. An increase in the price of uranium four-fold (from today's \$20/lb U_3O_8 price) would only lead to a 3.5 mill/Kwh electricity cost increase. This is roughly equivalent to a \$2/barrel increase in the price of oil. This is quite modest for a power-supply system in which costs have increased from 4 mills/Kwh to 20 mills/Kwh, in less than 10 years for reasons which have nothing to do with uranium prices.[2/] Nuclear power may be abandoned for any number of reasons, but it is in no danger of losing out to other fuels

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2/ Bupp, Irvin C., and Jean-Claude Derian,"The Breeder Reactor in the U.S.: A New Economic Analysis," Technology Review, July/August 1974, p.26.

because of higher uranium prices. As Professor David Rose of MIT notes, "economic introduction of the LMFBR at the turn of the century would be a sign of technology good fortune, not of resolving an energy crisis with a time limit."3/

The Atomic Energy Commission has now written and released three cost-benefit analyses of the LMFBR program.4/ In addition to the AEC's analyses, cost-benefit analyses of the breeder program have been performed by Alan S. Manne and Oliver S. Yu,5/ Richard Richels,6/ T. R. Stauffer, H. L. Wyckoff and R. S. Palmer.7/ In addition, Irvin C. Bupp and Jean-Claude

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3/ Rose, David J.,"Nuclear Electric Power," Science, Vol.184, No.4134, 19 April 1974, p.357.

4/ The first, written in 1968, was released in 1969; an updated (1970) analysis was released in May, 1972; and the latest (1973) analysis appeared first in the AEC's Draft and then with revisions in the Proposed Final Environmental Impact Statement on the LMFBR Program. [cited herein as PFEIS, LMFBR.]

5/ Manne, Alan S., and Oliver S. Yu, "Breeder Benefits and Uranium Availability," Nuclear News, January, 1975, p.46. Manne is a pforessor of political economy at Harvard's JFK School of Government and Yu is on the technical staff of the Electric Power Research Institute (EPRI)

6/ Richels, Richard, "The LMFBR Timing Issue," [draft], March, 1975. Richels is a graduate student under Manne at Harvard.

7/ Stauffer, T. R., Wyckoff, H. L., and R. S. Palmer, "The Liquid Metal Fast Breeder Reactor, Assessment of Economic Incentives," presented to Breeder Reactor Corporation (Chicago, Illinois), March 7, 1975. Stauffer is a Research Fellow at Harvard, Wyckoff is with Commonwealth Edison and Palmer is Manager, Business and Product Planning in the Fast Breeder Reactor Department of General Electric Corporation.

Derian have made an economic evaluation of the breeder program.[8/]

All of the cost-benefit analyses, including ours, depend critically upon the accuracy of assumptions regarding (a) the choice of the discount rate; (b) the cost of the breeder research and development program; (c) the capital cost difference between LMFBR's and conventional nuclear reactors; (d) the future demand for electricity; and (e) the domestic supply of uranium.

It is clear from a review of the economic analyses that have been performed on the breeder that the critical input assumptions can be juggled to come up with widely varying LMFBR cost and benefits. A tempting and too easy way out is to point to these varying conclusions and dismiss economic analysis on that basis. Yet the basic arguments for the current LMFBR program are economic, and it is essential that Congress look critically into these economic analyses to determine whose assumptions are in fact reasonable.

In order to appreciate the degree to which the economic analyses of the LMFBR prepared by the AEC and the nuclear industry suffer from a fatal promotional bias, one need only look at the electrical energy growth projection

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8/ Bupp, Irvin C., and Jean-Claude Derian, *op. cit.* Bupp is in the Center for International Affairs, Graduate School of Business Administration, Harvard, and Derian is at the Center for Policy Alternatives, M.I.T.

used by the AEC in its most recent analysis. The steepness of the growth curve, as depicted in the attached graph provided by the AEC, staggers the imagination.

A second area where the AEC resorted to unsupportable assumptions to justify the program is the issue of capital cost differences between LMFBR's and present-day reactors. It is possible to accelerate the date when breeders become economically competitive by arguing that as more breeder reactors are sold the unit price will be reduced. Economists refer to this possibility of decreasing costs with increasing number of units produced as "learning." Hence, a central issue is whether it is appropriate to apply a learning curve to the capital cost of LMFBR.* The AEC in its latest cost-benefit analysis applied a sharp learning curve to the breeder reducing its capital cost to parity with light water reactors in the short 13 year period following commercial introduction. Remarkably, light water reactors are assumed not to experience any learning at all. There is really no justification for this approach. The AEC has been predicting a learning curve in the cost of present day nuclear plants for the past decade.

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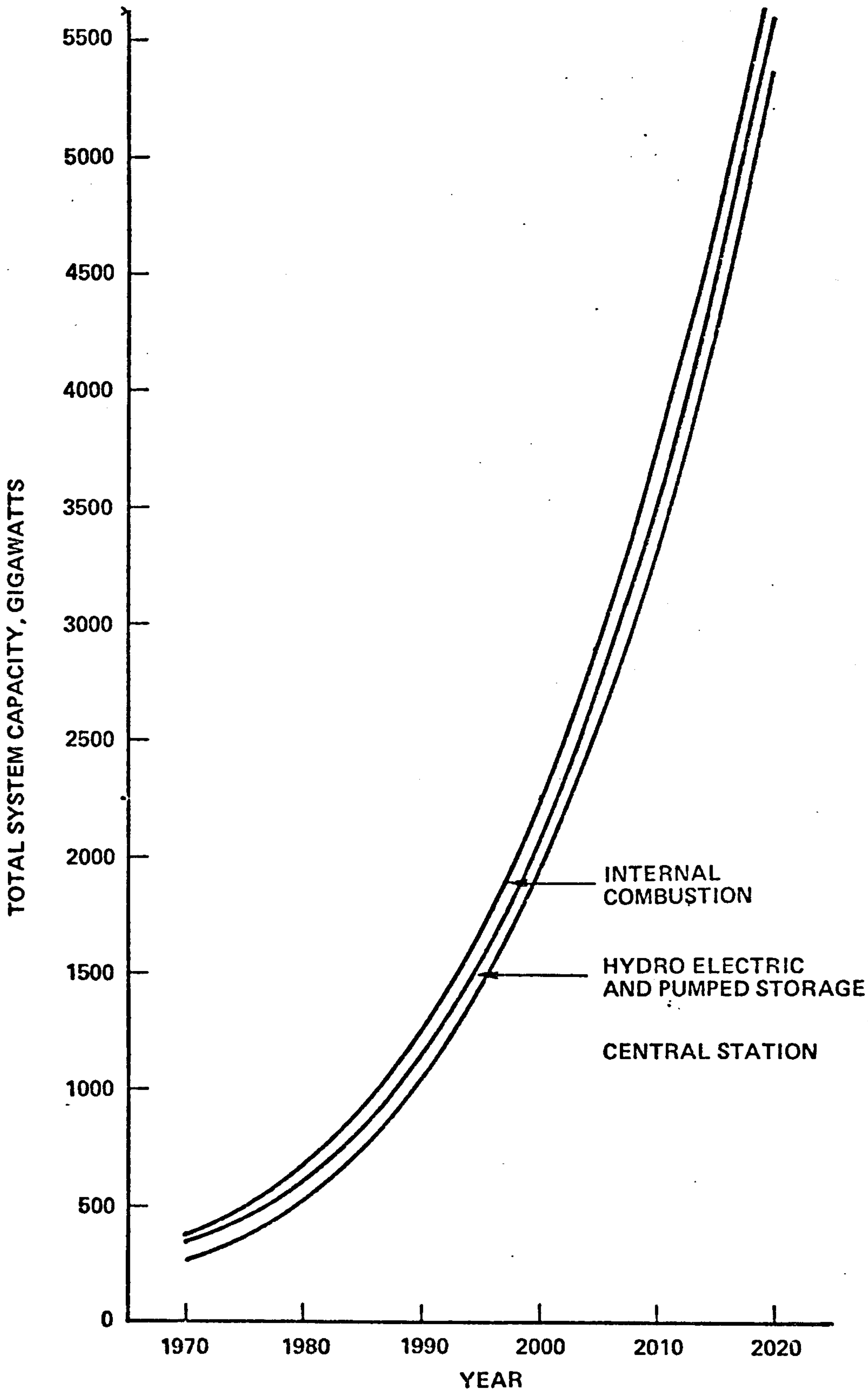
* This learning effect is separate from the subsidies associated with first-of-a-kind or prototype plants. The AEC has simply ignored these first-of-a-kind costs.



PROJECTED DEMAND FOR ELECTRICAL GENERATING CAPACITY 1970-2020

Source: AEC, Proposed Final Environmental Impact Statement for LMFBR Program (December, 1974), Vol. IV, p. 9.1-3.

To the contrary, the cost of commercial nuclear plants has been increasing at an alarming rate, even in constant dollars. So in fact there is no justification for assuming learning for either reactor type. Moreover, if a learning effect is ever experienced, it will be felt by light water reactors before it is felt by breeders. This would increase the capital cost difference between breeders and existing reactors and shift the date of LMFBR commercialization further into the future.

What makes the AEC's LMFBR learning curve even more unbelievable is that in the same short period, 1987-2000, when LMFBR capital costs are rapidly falling due to learning there is a shift to an advanced LMFBR design in 1991 and again in 1995. Furthermore, in 1990 plant unit sizes increase from 1300 MW to 2000 MW with an additional 12 percent decrease in price.

As mentioned earlier, one of the critical input assumptions is the domestic supply of uranium. A number of independent investigators, including Professor John Holdren[9/] at the University of California - Berkeley,

9/ Holdren, John P., "Uranium Availability and the Breeder Decision," Environmental Quality Laboratory, California Institute of Technology, 1973. EQL Memorandum No.8, January 1974.

Professor David Rose[10/] at MIT, Drs. Irvin Bupp and Jean-Claude Derian[11/] at Harvard and MIT respectively, and Milton Searl,[12/] Director of the Energy Supply Studies Program at the Electric Power Research Institute (EPRI), believe the AEC has been overly conservative in estimating the domestic supply of uranium. The Environmental Protection Agency in its review of the AEC analysis stated that, ". . . the uranium supply could be significantly greater than that projected for the [AEC's] base case."[13/] In our cost-benefit analysis we use a uranium supply curve that is more consistent with the EPRI estimate.

We believe that if the Congress undertakes a careful analysis of all the critical input assumptions it will come to share our conclusion that the LMFBR will not be commercially competitive with existing energy sources until one or two decades after the turn of the century. Yet the current LMFBR effort is aimed at having the new reactor developed by 1990, more than two decades before it could be economically attractive. In our view the LMFBR program is thus quite

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10/ Rose, David J., *op. cit.*

11/ Bupp, Irvin C., and Jean-Claude Derian, *op. cit.*

12/ Searl, Milton F., "Uranium Resources to Meet Long Term Uranium Requirements," Electric Power Research Institute (EPRI), EPRI SR-5 Special Report, November 1974.

13/ Environmental Protection Agency, "Comments on Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program," PF-AEC-A00106-00, p.3. April 1975.

premature and could be delayed substantially without incurring any risks relative to meeting future U.S. energy needs. The sense of urgency and crisis that program supporters have promoted to garner support for the LMFBR has no foundation in fact.

On simple economic grounds, then, the push to develop the LMFBR can and should be postponed. Moreover, such a delay would provide the time needed to show what many experts now believe to be the case -- that environmentally preferable, nonfission energy options can be made available in time to eliminate the need for the LMFBR altogether. What is proposed here is an energy program which should be able to provide an adequate supply of fuels and electric power without the commercial utilization of breeder reactors. This program would include:

- An intensive effort to develop the various forms of solar energy should be undertaken following the recommendations of the expert panels convened under National Science Foundation auspicies, An Assessment of Solar Energy as a National Energy Resource (1972) and Solar and other Energy Sources: Subpanel IX Report (1973).[14/] In estimates

14/ NSF/NASA Solar Energy Panel, An Assessment of Solar Energy as a National Energy Resource, National Science Foundation, Washington, D. C., December 1972; Alfred J. Eggers, et al., Subpanel IX Report: Solar and Other Energy Resources, National Science Foundation, October 27, 1973.

which it believed were not the highest possible, the first of these studies concluded that its recommended R&D program could result by the year 2020 in solar energy providing 35% of the nation's total building heating and cooling load, 30% of the nation's gaseous fuel, 10% of its liquid fuel, and -- most important for present purposes -- 20% of the electrical energy requirements.[15/]

- A major R&D effort devoted to exploitation of geothermal resources for electric generation should be launched. The Cornell Workshop on Energy and the Environment (1972) concluded that "[i]t appears that geothermal energy alone is capable of meeting all American power requirements for several centuries if the hot dry rocks resource proves to be practical."[16/] The Cornell Workshop, the National Science Foundation, and others have recommended that a program to establish the feasibility of hot rock geothermal in the next few years be given highest priority. Projections of the electric power available from geothermal resources range from 80 to 400 GWe in the year 2000, depending on

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15/ An Assessment of Solar Energy, ibid.

16/ Cornell Workshop on Energy and the Environment, Summary Report, Committee on Interior and Insular Affairs, U. S. Senate, May, 1972, pp.114-15.

assumptions made about the hot rock potential.[17/] The AEC recently estimated that geothermal heat could supply 6% of our electricity in the year 2020,[18/] but it is clear that the percentage could be much higher if hot rock geothermal develops as expected.

- The current effort to develop fusion power should be expanded. The AEC recently stated that "a successful, vigorously supported fusion program would be expected to lead to construction of a demonstration power reactor that would begin operation in the mid-1990's."[19/] The agency anticipated "commercial introduction of fusion power plants on a significant scale beginning in the early 21st century."[20/] Thus, it now appears that the demonstration fusion power plant is not far behind the LMFBR demonstration plant and that fusion plants can be available commercially for much of the period during which it was assumed the LMFBR would be critically needed. The AEC's overall estimate is that by the year 2020 about 8% of our electricity could come from fusion.[21/]

17/ See, *e.g.*, Walter J. Hickel, *et al.*, *Geothermal Energy*, NSF/RANN-73-003, University of Alaska, 1973, p.7; Dixy Lee Ray, Chairman, AEC, *The Nation's Energy Future: A Report Submitted to President Richard M. Nixon* (1973).

18/ PFEIS, LMFBR, Vol. IV, p.11.1-20.

19/ PFEIS, LMFBR, Vol. III, p.6A.1-191.

20/ PFEIS, LMFBR, Vol. III, p.6A.1-179.

21/ PFEIS, LMFBR, Vol. IV, p.11.1-22.

- Organic wastes provide another source of energy that should be developed. Organic wastes could account for 5% of the demand for electricity in the year 2000 but only 2% in 2020 due to more efficient practices in the solid wastes area.22/

- All of the above year 2020 percentage contributions, e.g., 20% for solar, 6% for geothermal, etc., are based upon the AEC's year 2020 energy demand forecast which assumes a continuation of extremely rapid growth in electricity demand. Several studies of the future demand for electricity have been carried out using more sophisticated forecasting techniques and taking into account the effects of the increasing price of electricity and other market factors. These studies suggest that actual future demand will be less than half of that projected by the AEC.23/ Moreover, as a supplement to market influences, it is apparent that the U.S. is moving towards a national energy conservation policy along the lines recently suggested by the House Committee on Science and Astronautics, the Council on Environmental Quality, the Ford Foundation Energy Policy

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22/ PFEIS, LMFBR, Vol. IV, p.11.1-21.

23/ The electricity demand issue is discussed in detail in the Appendix to Bypassing the Breeder, pp.21-28, and in NRDC Comments on Draft LMFBR EIS, Alternative Technology Options, PFEIS, LMFBR, Vol. VI.

Project and others.[24/] These groups all suggest that U.S. energy growth can be roughly halved without serious adverse repercussions on the American economy or lifestyle. When both market and policy influences are taken into account, we believe it is reasonable, in fact, conservative, to assume that electricity demand in the year 2020 will not exceed 50% of the AEC's astronomical projection.

As summarized in the attached table, these estimates of the potential contribution of solar, geothermal and fusion energy together with energy conservation measures indicate that these sources alone can more than account for the energy expected from the LMFBR in the year 2020, when the reactor is projected to have maximum impact. Indeed, they can account for the energy expected from all fission reactors at that time.

These considerations indicate that a major LMFBR effort is not needed now and probably never will be. And the risks of continuing the present drive to commercialize the LMFBR are great. The most serious danger is that the LMFBR program will proceed as now planned, consuming the

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24/ Conservation and Efficient Use of Energy, Report of the Committee on Science and Astronautics, U.S. House of Representatives, December 18, 1974; Council on Environmental Quality, "The Half and Half Plan for Energy Conservation," printed in Fifth Annual Report of the Council on Environmental Quality (1974), p.475; Energy Policy Project of the Ford Foundation, A Time to Choose (1974), Chapters 3-6.

Table I

Energy Sources for Electricity Production in the Year 2020 Without the Breeder

	Trillions of Kilowatt Hours	Percent of AEC Projection	Source
AEC Projection	27.6	100	(1)
New Energy Sources			
Solar	5.5	20	(2)
Geothermal	1.7	6	(3)
Fusion	2.2	8	(4)
Organic Wastes	.6	2	(5)
	10.0	36	
Correction for Market Factors and Energy Conservation	13.8	50	
Total Accounted For	23.8	86	
Remainder for Other Sources (principally fossil fuels)	3.8	14	

Sources:

1. Proposed Final EIS for LMFBR Program, Vol. IV, p. 11.1-25
2. NSF/NASA, Solar Energy as a National Resource (1972), p. 5. Proposed Final EIS for LMFBR Program, Vol. IV, p. 11.1-19
3. Proposed Final EIS for LMFBR Program, Vol. IV, p. 11.1-20
4. Proposed Final EIS for LMFBR Program, Vol. IV, p. 11.1-22
5. Proposed Final EIS for LMFBR Program, Vol. IV, p. 11.1-21

$10 billion presently estimated and plenty more besides, cutting deeply into energy R&D funds, and holding back the development of the preferable non-fission technologies. Then, having spent enormous sums the country will find itself with a reactor which must eventually be used only because of the great public and private investments in it and our failure to have developed appropriate alternatives. Our error will be compounded because any attempt to deploy the LMFBR widely would raise the energy-environment confrontation to an unprecedented intensity.

The last refuge of the breeder proponent is the argument that the LMFBR is needed as an "insurance policy." I do not share this view. Ample insurance exists partly in pursuing a variety of non-conventional energy sources and energy conservation and partly in realizing that the AEC would insure us against a non-existent risk -- the risk that our electrical generating capacity will actually grow as that agency projected.

Furthermore, the insurance argument cuts both ways. While proponents of nuclear power wish to insure against the depletion of low cost uranium, opponents wish to insure against catastrophic breeder accidents, nuclear terror and blackmail. We can purchase both policies by continuing much of the LMFBR base program R&D and the LMFBR safety research, gathering operating experience with the Fast Flux Test Facility, but relegating the overall program to a low-priority status by foregoing any expensive push towards demonstration and commercial reactors. At the same time we could accelerate the development of attractive non-fission alternatives such as solar, geothermal, fusion and energy conservation. During the intervening years while the commercial component of the LMFBR program is delayed, much can be learned about uranium availability, future energy demand, and about LMFBR's component development from foreign programs. Furthermore, postponing the commercial component of the LMFBR program one to two decades does not permanently eliminate the LMFBR option. If within about a decade it becomes clear that possible non-fission options are not going to be available, consideration can be given at that time to reinitiating the full program. One could proceed with the CRBR or more probably would proceed with a demonstration plant of another size and a different design, and possibly with a different management and cost sharing structure. There would be no penalty for such postponement.