Bypassing the Breeder

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Editor's note: The following article is condensed from a recent report by the authors.

At a time of soaring power costs and pressing energy needs, federal energy officials are giving prime attention to the development of a new nuclear power source which for the next 35 years or longer will not be able to produce electricity as cheaply as existing sources. The new form of nuclear power also promises to be more hazardous and problematic than today's nuclear reactors and has been plagued with mammoth cost overruns which now threaten to undercut research and development funding for preferable energy alternatives.

This multi-billion dollar white elephant is the Liquid Metal Fast Breeder Reactor, or LMFBR for short. Raised to preeminence by former President Nixon, who later confessed that "all this business about breeder reactors and nuclear energy is over my head," the LMFBR now dominates the federal government's energy research and development program. During the coming fiscal year the new Energy Research and Development Administration (ERDA) plans to spend $1.66 billion to research and develop energy alternatives. Of this amount, over $490 million is to be spent on the breeder reactor program -- roughly one-third of ERDAs energy R&D budget and more than the combined allocations to fossil energy development ($311 million), solar energy development ($57 million), geothermal energy development ($28 million), advanced energy research ($23 million) and energy conservation ($32 million).

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The latest government estimate predicts the total cost of developing the LMFBR will be $10 billion and this figure, developed by proponents of the program, is certainly conservative. Already the LMFBR program has experienced tremendous cost overruns. Two years ago total costs were put at less than half of today's estimate. The price tag on the program's principal test reactor, the Fast Flux Test Facility at Hanford, Washington, was originally $87 million but has now risen more than tenfold to $933 million.

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Congress was told in 1973 that the proposed Clinch River Breeder Reactor Demonstration Plant to be built near Oak Ridge, Tennessee, would cost $700 million. Today the government's estimate has soared to $1.7 billion.

The burden of this immensely expensive program falls on the American taxpayer. It would be comforting if such expenditures could be justified, but unfortunately they cannot, for the breeder reactor program is neither needed nor desirable.

The stated justification for the LMFBR runs along the following lines. As the nuclear power industry expands, the U.S. is slowly depleting its low cost uranium reserves, with the result that the price of uranium is rising and will continue to rise. The principal substitute for uranium is plutonium, a man-made element produced in nuclear reactors. Since the LMFBR generates about twice as much plutonium as existing reactors, its use would greatly expand the supply of nuclear fuel, perhaps 50-fold, and accordingly hold down its price.

Because of the LMFBRs ability to produce more fuel than it consumes, the Atomic Energy Commission (AEC) made the commercialization of the breeder reactor its highest priority project in the mid-1960s. The current program is geared to introduce the commercial LMFBR by about 1987.

The now-defunct AEC performed three cost-benefit analyses of the LMFBR program, the latest of which appears in the Proposed Final Environmental Statement for the program. The agency consistently found the breeder's benefits to outweigh its costs, although given the AECs former dual role of both promoting and regulating the industry, the cost-benefit analysis must be approached with skepticism. Indeed, the Environmental Protection Agency recently labelled the AECs Draft Environmental Impact Statement on the breeder as inadequate, finding the document "particularly deficient in its treatment of reactor safety, in potential problems associated with plutonium toxicity and safety, and the cost-benefit analysis."

When cost-benefit methodology is applied to the LMFBR, the results have a direct correlation to certain assumptions made about the program, such as:

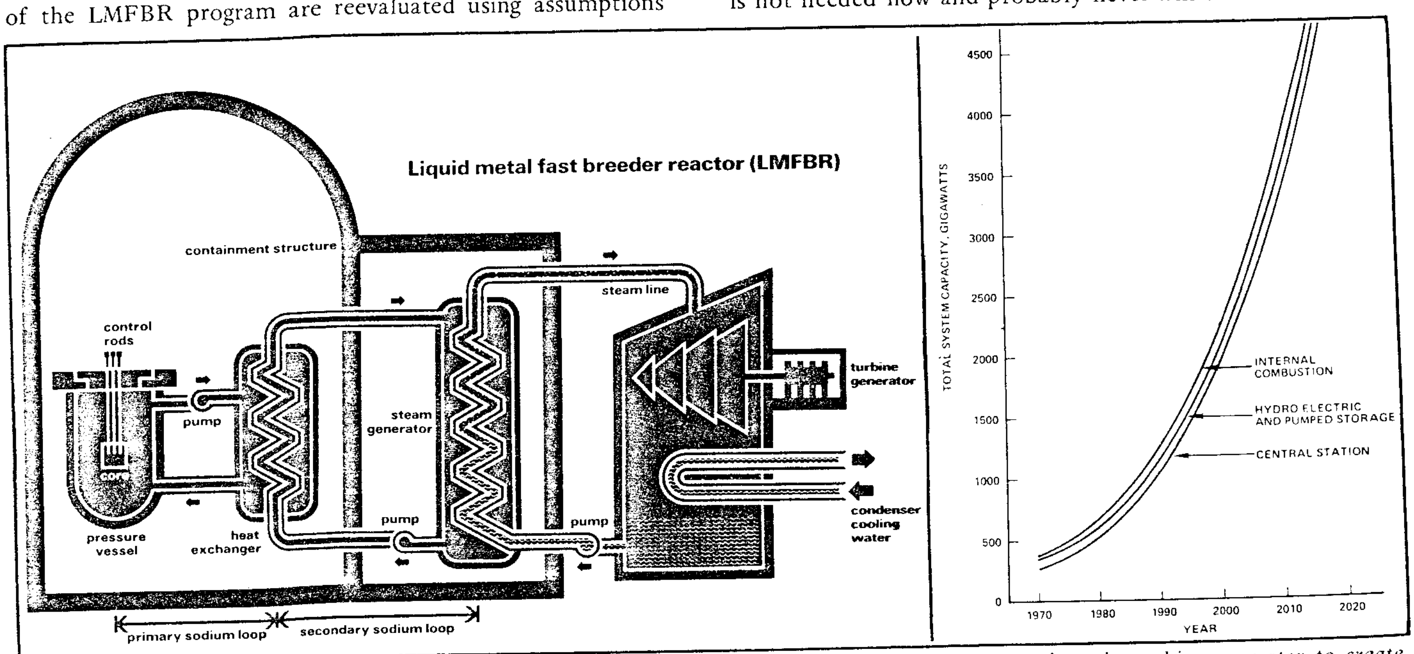
- the difference in construction costs between the breeder and conventional reactors;
- the anticipated supply of uranium;
- future electrical energy demand;
- the rate at which conventional reactors penetrate the utility market;
- the rate at which future benefits are discounted to make them comparable with today's expenditures;
- the total cost assumed for researching and developing the program;
- and reactor performance data for the breeder.

The first three of these variables are extremely important. The AEC succeeded in making the LMFBR appear attractive by making very favorable but very unrealistic assumptions in each of the seven areas listed. But when the economic merits of the LMFBR program are reevaluated using assumptions and data from experts independent of the AEC, the expected economic benefits are only a small fraction of its R&D costs. For every $10 spent on developing the breeder, the public will get back only $1 or less in lower energy costs. Only when a series of highly unrealistic assumptions are made can such analysis suggest that the LMFBR program will produce net economic benefits.

These results indicate that the commercial introduction of the breeder can be delayed substantially, probably two decades or more, without economic penalty. For much of the period covered in the AECs cost-benefit analysis (1987-2020), the LMFBR cannot compete economically with alternative sources, largely because of its high construction costs. Until the price of uranium rises sufficiently to offset the extraordinary investment costs of the LMFBR, consumer-minded utilities will continue to prefer existing reactors and other energy sources. Our analysis indicates that the LMFBR will not gain a competitive edge until after the year 2010. This date is approximately two decades beyond the target for commercial introduction in the current program schedule.

On simple economic grounds, then, the push to develop the LMFBR should be postponed. More important, such a delay would provide the time needed to show what many experts now believe to be the case – that environmentally preferable, non-fission energy options can be made available in time to eliminate the need for the LMFBR altogether. Recent 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



Here's how it works. The breeder reactor, like standard fission reactors, is really an elaborate water kettle. Nuclear fuel is fissioned in the core, heating molten sodium which passes in a primary loop through the core. The heat in the sodium is transferred to a second sodium loop in the heat exchanger and then pumped to the steam generator. The steam is pumped to the turbine generator to create electricity. Plutonium "breeded" in the core is extracted periodically and reprocessed into new fuel. Chart on right shows electricity growth projected by the former AEC. (Drawing courtesy of the Atomic Industrial Forum)

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of continuing the present drive to commercialize the LMFBR are great. The most serious danger is that the program will proceed as now planned, consuming the $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. This error will be compounded by the unprecedented environmental risks of operating breeder reactors.

The LMFBR program has proceeded in the face of mounting apprehension within the scientific community concerning the human and societal hazards of generating power with nuclear fission. Scientists at the 23rd Pugwash Conference on Science and World Affairs in September, 1973, concluded that the LMFBR would not eliminate any of the hazards now associated with nuclear power and in critical respects would actually increase them.

The LMFBRs principal function, to "breed" extraordinary amounts of plutonium, is also its chief danger. According to government estimates, as much as 30,000 tons of plutonium may be produced in nuclear reactors by the year 2020, and most of that amount would come from the breeder. By multiplying the intolerable risks of utilizing plutonium, the LMFBR will pose hazards the U.S. is not yet equipped to handle (*EA*, Nov. 23, 1974).

As events are making us painfully aware, plutonium is probably the most dangerous substance known. It is fiendishly toxic: a millionth of a gram has been shown capable of producing cancer in experimental animals. Plutonium-239, the principal isotope of the element, has a half-life of 24,000 years, so that its radioactivity is undiminished within human time scales.

Plutonium is also the substance from which nuclear weapons are made. An amount the size of a softball is enough for the production of a nuclear explosive capable of mass destruction. Scientists widely recognize that the design and manufacture of a crude atomic bomb is not a technically difficult task, a fact dramatized recently when a Massachusetts Institute of Technology undergraduate successfully designed a nuclear weapon for an educational television program. The only real obstacle to the building of homemade atomic bombs is the availability of plutonium itself. But now, first with the proposed use of plutonium in today's reactors and even more with the introduction of the LMFBR, this final obstacle would be removed. In the "plutonium economy" envisioned by the AEC, the development of a plutonium black market and nuclear theft and terrorism become high probability events — threats which have spurred nuclear proponents to urge the creation of a federal security system that would meddle with our civil liberties on a vast scale.

In addition, operating the breeder reactor — independent of the plutonium problem — is believed to be even more dangerous than today's light water reactors. The LMFBR core, where the heat is generated, is far more compact than a light water reactor core and instead of the water used to cool conventional reactors, the LMFBR uses liquid sodium, an opaque and highly reactive element. Partial loss of coolant would increase the nuclear reaction in the core rather than reducing it. The LMFBRs operation is extremely sensitive to fuel motion and loss of coolant from the core in accident situations, leading to the possibility of an explosive nuclear runaway. In the event of a meltdown, the breeder's highly enriched fuel can rearrange itself into a more compact configuration, making possible small nuclear explosions of sufficient force to breach the reactor containment. There are major uncertainties in defining the explosive potential of the breeder, which are all the more worrisome considering the several tons of plutonium contained in its core.

For these reasons, a decision to commit this nation to the LMFBR may prove to be the most significant technological decision since the Manhattan Project. The breeder reactor decision is literally a decision for all people and all time.

The new Energy Research and Development Administration, which took custody of the breeder program with the AECs demise, should, in light of these facts, take this opportunity to reverse past mistakes. It should postpone for a decade or more the push to commercialize the breeder reactor and cancel the Clinch River demonstration plant. The overall program should be relegated to a low priority effort during this time and the funds saved by this step should be used to help accelerate the development of non-fission alternatives such as solar, geothermal, and fusion power and energy conservation.

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A fission-free option to the LMFBR which can provide reasonably priced and environmentally acceptable energy almost certainly exists and can be made available within a suitable time frame. The claim that the LMFBR or other breeder reactor is in any sense necessary must be rejected — the breeder is no more necessary than we make it by refraining from developing other technologies. An energy program that should be able to provide an adequate supply of fuels and electric power without the commercial utilization of breeder reactors would contain the following major elements:

- 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 auspices. (*An Assessment of Solar Energy as a National Energy Resource*, 1972, and *Solar and other Energy Sources: Subpanel IX Report*, 1973.) In estimates the author described as conservative, the first of these studies concluded that its recommended R&D program could result by the year 2020 in solar energy providing 35 percent of the nation's total building heating and cooling load, 30 percent of the nation's gaseous fuel, 10 percent of its liquid fuel, and – most important for present purposes – 20 percent of the electrical energy requirements.

- 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 concluded in 1972 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." 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 gigawatts in the year 2000, depending on assumptions made about the hot rock potential. The AEC recently estimated that geothermal heat could supply 6 percent of our electricity in the year 2020, 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 predicted 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-1990s." The agency anticipated "commercial introduction of fusion power plants on a significant scale beginning in the early 21st century." 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 AECs overall estimate is that by the year 2020 about eight percent of our electricity could come from fusion.
- Organic wastes provide another source of fission-free energy that should be developed. Here the AEC estimates that organic wastes could account for five percent of the demand for electricity in the year 2000 but only two percent in 2020 due to more efficient practices in the solid waste area.
- All of the above year 2020 percentage contributions, (20 percent for solar, six percent for geothermal, etc.) are based upon a year 2020 energy demand that assumes a continuation of extremely rapid growth in electricity demand. Such projections yield an electricity consumption in the year 2020 that is over *15 times* today's, a result widely regarded as completely unrealistic. The electricity growth projection used by the AEC to justify the LMFBR program is shown in the chart on page 11. The steepness of the curve staggers the imagination. Recent studies of the future demand for electricity, taking into account the effects of the increasing price of electricity and other market factors, suggest the actual future demand will be less than half of that projected by the AEC. Moreover, as a supplement to market influences, it is apparent that the U.S. is moving toward a national energy conservation policy along the lines recently suggested by the House Committee on Science and Astronautics, the President's Council on Environmental Quality, the Ford Foundation Energy Policy Project, and others. These groups all suggest that U.S. energy growth can be roughly halved without serious repercussions on the American economy or lifestyle. Thus when both market and policy influences are taken into account, it is reasonable, in fact, conservative, to assume that electricity demand in the year 2020 will not exceed 50 percent of the AECs astronomical projection.

So it is very possible that over 80 percent of the electricity demand projected by the AEC for the year 2020 can be accounted for principally by a combination of solar, geothermal, and fusion energy together with more accurate forecasting of energy demand. This percentage is larger by a substantial margin than the LMFBRs contribution predicted for that year by the AEC (50 percent) and, indeed, is larger than the contribution the AEC expected from nuclear fission generally (70 percent).

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The funding needed for this alternative energy strategy would be high, but not unacceptably so. AECs last official projection of future LMFBR expenditures, $8 billion to program completion, exceeds a recent Federal Power Commission estimate of the total R&D costs of developing all non-nuclear technologies, including coal gasification, solar (direct and indirect) and geothermal technologies, advanced steam cycles, fossil fuel effluent controls, and a variety of energy storage systems. The FPC estimate of $6 billion, however, does not include the cost of developing fusion systems, which is expected to be comparable to that of the LMFBR.

The last refuge of the breeder proponent is the argument that the LMFBR is needed as an "insurance policy." Careful consideration indicates that this is simply not the case. Ample insurance exists 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. Moreover, relegating the LMFBR program to low priority status and foregoing any expensive push toward demonstration and commercial reactors for from one to two decades does not permanently eliminate the LMFBR option. If within about a decade it becomes clear that options to nuclear fission will not be available, consideration can be given at that time to reinstating the program. The idea that there is a penalty for such a postponement, as we have shown, is wholly spurious.

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 suggested here would provide an opportunity to correct that mistake – before it is too late. Construction is scheduled to commence on the Clinch River demonstration plant later this year, with the necessary approval coming much sooner. Once these hurdles are cleared, it will be far more difficult to reorient this increasingly massive program. ■