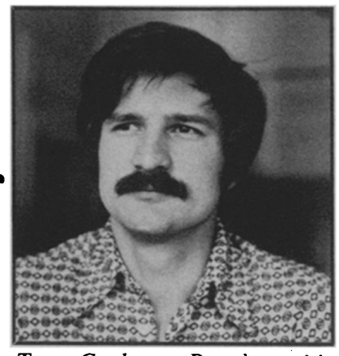
Breeder Reactors

A Faustian Dilemma: Unlimited Power Or Unparalleled Risks?



Tom Cochran: Breeder critic

by Janet H. Weinberg

While alternative energy technologies are discussed with varying degrees of interest by the public and industry, the Government is quietly and heavily funding its priority alternative, the liquid metal fast breeder reactor (LMFBR). President Nixon told Congress in 1971 that "Our best hope for meeting the nation's growing demand for economical clean energy lies with the fast breeder reactor." The Atomic Energy Commission (AEC) has since devoted a large portion of its budget and attention to research, development and justification of the breeder.

Later this month, public hearings will begin on the draft version of an environmental impact statement the AEC issued in March on the LMFBR program. Since the draft report was made public, the AEC has received 1,500 pages of response. Under the National Environmental Protection Act, these reactions must be published along with the commission's responses in the final draft of the report, expected to come out in early fall. Public hearings must also be held, and many AEC officials and LMFBR opponents are gearing up for them now. It seems an appropriate time to review the breeder program and the controversies surrounding it.

Although the breeder is the Government's priority alternative to fossil and conventional nuclear power plants, it is not the alternative of choice in many circles. Breeder critics object to many technical aspects that are common to it and light-water power plants, but also to some that are generic to the breeder. For this reason, a quick review of how the breeder works might be helpful before considering the specific objections.

Sustained, controlled nuclear fission depends first on the tendency of elements such as uranium and plutonium to emit neutrons in the course of fission. In order for controlled fission to occur, an average of one neutron per fissioned atom must strike another fissionable nucleus. The uranium isotope U235, is generally used in conventional nuclear power plants as the fissionable fuel. More than one neutron, usually about 2.5, is emitted, so other substances are made available to absorb the extra 1.5 neutrons and to slow all of the neutrons so at least one will have a good chance of finding its target. Control rods made of neutron-absorbing boron, and water, which both cools the reactor core and slows down the neutrons, are used to moderate and control the reaction. As in fossil fuel plants, heat released by the fission reactions is used to boil water, make steam, drive turbines and generate electricity.

Almost since man began to understand nuclear fission and its inherent potential for energy production, he has theorized that the breeding of fuel could be accomplished. If the extra 1.5 neutrons were used to turn fertile fuel (such as U238, Pu240 or Th232) into fissionable fuel (such as U233, Pu241 or Pu239) he would gain back what he used up, plus some. This he has essentially been able to do in test breeders and proposes to do on a commercial scale.

In a breeder reactor such as the LMFBR, no moderator is used, thus the reaction is considered "fast." An average of one neutron from each fuel atom (Pu239 is used) carries on a chain reaction with other plutonium atoms. The extra 1.5 neutrons are absorbed by a blanket of fertile material such as U238, which then decays rapidly to form Pu239. This is removed periodically from the reactor and made into fuel for other breeders or for light-water reactors which can also run on Pu239. Flowing around the immensely hot fuel rods inside the reactor core as a coolant is molten sodium, a silvery metal with some useful properties. It does not moderate neutrons, and thus does not interfere with the fast reaction; it is a good heat-transfer agent, and it also has a very high boiling point. The reactor can operate at a high temperature (between 800 and 1,050 degrees F.) without requiring high pressure to prevent the sodium from boiling. This eliminates the necessity for high pressure and the worry over pressurized pipe ruptures and subsequent coolant loss that has plagued the operators of light-water reactors. This low pressure is a good thing because a ruptured sodium pipe would create quite a mess. Sodium bursts into brilliant yellow flame on contact with air.

The developers of the breeder in the United States, the AEC and industry (which is contributing to breeder research and development) justify the program for several reasons. First of all, the breeder will increase the energy available in uranium. Light-water reactors use U238 enriched with U235, and in the process of extracting the .7 percent of U235 that occurs naturally and concentrating it to 3 percent for fuel, much U238 is left unused. Massive stockpiles of "tailings" have been set aside, and these can be used as a fertile neutron acceptor. Also, because more plutonium will be produced than consumed by the breeders, plutonium can be used in light-water reactors. The cost of uranium is also considered. The AEC projects that low-cost uranium deposits are fairly limited and that the breeder could use high-cost deposits more efficiently. AEC's Division of Waste Management and Transportation Plans Branch chief Harvey Soule predicts that after about the year 2020, uranium will no longer have to be mined at all.

The need for additional fuel enrichment plants would be circumvented, and breeder proponents predict that electricity would be considerably cheaper than if produced with fossil fuels at their inflated costs toward the end of the century. Also, because the breeder would have a higher thermal efficiency, less hot-water pollution would be made per unit of electricity produced.

Explained in this way, the breeder sounds like a nearly perfect solution to man's energy problems. The AEC, while exploring other alternatives, has been operating under this premise for many years. The first breeder, an experimental reactor called Clementine, was developed at Los Alamos National Laboratory in 1946. The first electric power from a nuclear reactor was generated by the Experimental Breeder Reactor I, built near Arco, Idaho, in 1951. Two more test breeders, the Experimental Breeder Reactor II in Idaho, and the Enrico Fermi Atomic Power Plant on Lake Erie in Michigan,

have been in operation since the mid-1960's.

Encouraged by these programs, the AEC established the LMFBR program as its highest priority commercial reactor program. They reported this to President Johnson in 1967, and have been supported in their efforts by the Nixon Administration and the Joint Committee on Atomic Energy. A Fast Flux Test Facility is being finished now in Hanford, Wash., and will be used to test materials and fuels. Already in the beginning stages is the first prototype commercial breeder, the LMFBR Demonstration Plant, to be built along the Clinch River in Tennessee.

An environmental impact statement was issued on the demonstration plant in April, 1972. The AEC would not normally have issued another statement on the breeder program (subsequent statements will, of course, be made individually for each planned commercial breeder at its proposed site). But in 1971, the Scientists' Institute for Public Information brought suit against the AEC to force the publication of a statement on the impact of the breeder program in general. The U.S. Court of Appeals for the District of Columbia ordered last summer that the statement be written, and it is this draft which will be reviewed in the upcoming public hearings.

What the AEC has often failed to emphasize in its benefit projections are the hazards and risks associated with breeders. Breeder skeptics have lost no time zeroing in on these risks.

Two organizations, the Environmental Protection Agency (EPA) and the National Resources Defense Council (NRDC, a nonprofit organization of scientists and laymen based in Washington) reviewed the environmental impact statement issued in March. Both groups gave the statement a failing grade, and submitted to the AEC over a thousand pages of specific criticisms and suggestions. EPA's Director of the Office of Federal Activities, Sheldon Meyers, emphasized that the agency's criticisms were aimed at the statement itself, and not the LMFBR program in general. NRDC physicist Thomas Cochran openly states his position that the breeder is an unacceptable energy alternative.

Both groups object to the cost-benefit analysis used by the AEC to show the economic advantages the breeder affords and the necessity for funding the program at its present level. The analysis assumes that rising costs in other fuel technologies and for uranium will make the breeder favorably competitive and that an early introduction of commercial breeders is essential. The EPA says in its assessment that there are several methodological flaws such as the use of a low discount rate and certain capital cost estimates. Analysis with their methods show the breeder need not be pushed so quickly, and that there is time to "consider other uranium conserving technologies and . . . study and resolve some of the issues of environmental risk."

A major objection put forward by the NRDC is that the cost-benefit figures rely heavily on the projection of available low-cost uranium. They contend that the AEC is basing its projections on limited information about the total availability of low-cost deposits. "Their information," Cochran says, "is based on incomplete exploration of less than 10 percent of western uranium areas." NRDC calculations, admittedly crude, show at least 13 million tons of low cost uranium while the AEC projects only about .7 million.

The AEC in conjunction with the U.S. Bureau of Mines has begun a program to assess uranium resources nationwide, AEC economic analyst Saul Strauch says, and will have complete information in about 5 years. Questions remain in some minds about the sense of continuing the program at full speed before such an assessment is known, and about the original decision to support the breeder which was so heavily justified with cost-benefit figures based on future fuel reserves and prices.

Strauch says critics have failed to consider the importance of inflation in the cost-benefit picture. Greatly inflated coal and oil costs will make the breeder attractive regardless of the price per pound of uranium, he said.

Another major issue discussed in the EPA and NRDC assessments and publicly debated is the question of safeguards. Plutonium can also be used to make nuclear weapons. Criticisms have been leveled at the lack of safeguards now surrounding nuclear fuels during storage, shipment and use, and the attention paid this subject in the environmental draft statement. Many feel that growing world terrorism is an *a priori* reason not to make more potentially devastating materials available during the nuclear fuel cycle. Soule says the AEC is well aware of the safeguards issue, and is now discussing two possible solutions.

"There has been discussion of moving plutonium through the weapons transportation system, not the industrial transportation system. This is, of course, much more rigorous." In one sense, then, terrorists interested in stealing nuclear weapons materials could just as easily steal the whole weapon and not bother with handling radioactive materials.

"Another concept," Soule says, "is that of nuclear-energy centers. All aspects of the fuel cycle, fuel reprocessing, enrichment, the power plant itself, and the waste storage, would be located within one protected area. There would then be fewer inter-site shipments and elimination of the weak link in the cycle."

Cochran wonders who would want to live near one of these centers.

Besides plutonium's weapons potential, it is a highly toxic substance. If it were dispersed into the atmosphere by an accidental release or even through routine low-level emission, some think it could cause lung cancer. In its draft statement, the AEC acknowledges that little data are available on the health effects of plutonium. The EPA and NRDC stated that some projected risks should be included in the final draft statement so the breeder's full impact on public health can be assessed.

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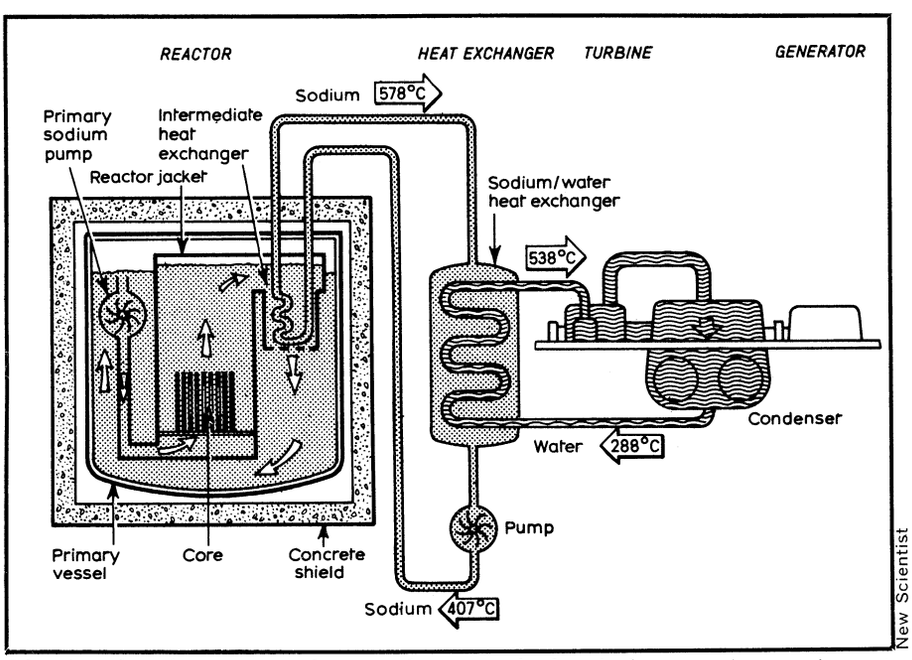

The fast breeder reactor, heat exchange and electrical generating equipment.

. . . Crash

shoulder harnesses.

Only two aircraft have been crashed so far, on Feb. 7 and May 8. These, plus a third scheduled for June 26, have been stripped-down vehicles without engines, tails, landing gear and other components, but with solid ballast replacing some of the parts and water in the fuel tanks, providing almost normal weight of about 6,000 pounds. Late in September the Army will step in with a super-crash of its own, a 30,000-pound CH-47 "Chinook" helicopter (with a full "crew" of nine dummies). After that, NASA will begin using its 20 complete aircraft, with 11 more stripped-down ones to be inserted at various points to test particular ideas or problems as they arise in the course of the program.

It is far too early for quantitative results to be available, and most of them will be in the form of numerical values to be used in fine-tuning subsequent computer simulations. Both NASA and the FAA agree, however, that even the first crash revealed what had been a widespread misconception in the limited studies of the past: "It was brought home to us loud and clear," says Langley's Robert Thomson, that there are two, not one, major impacts in a crash.

The assumption had been that a plane hitting the ground nose first gets one big jolt which is then transmitted rearward through the structure. The tests show that after the nose hits, the shock of the fuselage falling to earth behind it is a second substantial blow. At 60 miles per hour, says Thomson, the vertical loads in the second shock may be as high as 50 times the force of gravity, although they last for only two or three hundredths of a second.

The goals of the NASA and FAA research (the FAA will probably do its Atlantic City catapulting as the NASA data develop) are several. Most of the project officials at both agencies speak in terms of "developing the tool," meaning the computer analysis technique on which they must rely in the future when there are no flood-damaged airframes to throw around. It seems likely, however, that at some point the data will go into helping the FAA draw up more accurate, useful and rationally based safety standards for general aviation manufacturers. Improved safety would seem an almost certain result, although officials are reluctant to suggest that the program will result in anything that sounds like clamping down on the plane-builders. "Remember," goes the line, "it's not consumer testing."

True enough, but thanks to deadly Hurricane Agnes, the consumer—pilot and passenger alike—should benefit.

. . . Breeders

Two more major issues have gained attention; the problem of radioactive waste storage and the uncertainty over reactor safety and potential accidents.

Many radioactive wastes (highly radioactive by-products produced during fission and fuel processing) will have to be stored for thousands of years before the radioactivity has died down completely. Some of the fission products are short-lived, but some, like plutonium, will emit neutrons for over 200,000 years. Breeder wastes essentially will not differ from other nuclear wastes, but there may be more of them, Soule said. The AEC is researching ways to store the wastes in stable geologic formations that have been undisturbed by seismographic activity for 200,000 years, which have not undergone any geologic changes in that time, and which do not drain into water tables.

"We are now investigating the possibilities of using dome salt formations, granite, limestone or shale deposits. Our criteria for choosing a site for geologic storage will be to find one where materials can be confined without maintenance indefinitely. It must be close enough to the surface to excavate and yet not so close that there are worries about people in the distant future wanting to get in to mine valuable minerals, or getting in by accident or erosion. The minerals we are investigating are so abundant, close to the surface, that it is hard to conceive of someone wanting to drill down 5,000 feet in order to get them out," Soule said.

In addition to researching long-term geologic storage, Soule outlined three proposed methods of retrievable surface interim storage. (Wastes would be stored on a short-term basis, perhaps 10 to 30 years, Soule said, until a suitable long-term method is chosen.) (1) Stainless steel basins filled with water inside reinforced concrete modular buildings could hold sealed canisters of hot wastes. This method is already being used in several locations. (2) The canisters could be sealed in concrete vaults designed with vents so that air enters at the bottom, cools the canister and rises by natural convection, carrying away the heat passively. "Where there is no electrically powered cooling system, there is none to conk out," Soule said. These vaults would sit on a paved surface in a guarded, enclosed area. (3) Wastes could be sealed in individual casks made of steel and concrete that would sit on a paved, guarded surface and be cooled by the air.

The EPA and NRDC assessments came down heavily on the AEC's waste-management proposals. The EPA is concerned that the reliability of current low-level waste storage has not been demonstrated, and that no long-term method is in sight. Cochran says, "We are 25 years into the nuclear age, and we have no permanent storage method, and the interim storage methods are unsatisfactory. There would be more radioactivity stored at one of these interim repositories than from a full scale nuclear war. A person could drive up to one in a van with a small nuclear weapon inside, or shoot one from a small cannon." If the weapon exploded and vaporized the canisters, the radioactive wastes would be carried up in a mushroom cloud and dumped all over the earth, he said.

The last major issue, reactor safety, is a complex one. Because the LMFBR would have a fast, unmoderated reaction, the time for safety systems to scram and shut down the reactor would be much shorter than for slow reactors. In a light-water reactor, there is no possibility of a nuclear explosion taking place, but a small one is possible in an LMFBR. The AEC says that the probability of the sequential accident factors necessary to bring on a nuclear explosion is tiny, and makes the event "extremely unlikely." The NRDC contends that such words are subjective, and that not enough solid data exist on the probability of an accident for realistic assessment of the risks to be made.

There are probably no right or wrong answers to the breeder issues—only degrees of confidence. The AEC demonstrates a traditional American "can-do" attitude. Whatever technological problems exist, they are convinced that the answers lie within the grasp of the scientific mind and the computer. And they have certainly overcome immense design and engineering problems in demonstrating the breeder thus far.

But Cochran feels they haven't come far enough. "They are more confident than I am about their computer codes, about their ability to fabricate equipment without flaws, about the possibility of operating the breeder without human failure, and about the backup and safeguards systems. I don't see the need for the breeder in the time frame they are projecting, and developing a technology before it is economically useful is a waste of money."

At this point, EPA plans to circumvent the upcoming public hearings, and instead, hold a series of meetings with the AEC to work out questions left unanswered in the environmental draft statement. After the meetings, Meyers said, "The AEC will have to decide what changes to make, if any. They don't have to do anything, but if they find our comments valid, we hope that they will alter some of the breeder plans in favor of the environment." □