EXCLUSIVE

The Fast Breeder Reactor: Its Political, Economic And Scientific Implications

The major focus of the virulent opposition to nuclear fission generated power on the part of the New York financial community and such allied "environmental" organizations as Laurance Rockefeller's Natural Resources Defense Council, has become an escalating attempt to completely terminate the development of the fast breeder reactor, both in the United States and abroad. President Carter's recently proposed budget cuts of $200 million in the breeder program and his administration's support of the recommendations of the Rockefeller Brothers Fund-sponsored report, the "Unfinished Agenda" which advocates the phasing out of nuclear power over the next 10 years, clearly implicates him in this effort.

The main attack on the breeder reactor has been couched under three outright bogus issues, the so-called "dangers of plutonium," "nuclear terrorism," and "nuclear proliferation," coupled with a schwärmerei of Naderite-inspired environmental issues. To the politically naive person, these issues may appear legitimate, but a look underneath these "doomsday cries" will identify quite different real reasons for the vicious attack on nuclear power and related forms of progress and industrial development.

Monetarists' Policy of De-Industrialization

The real issue is simply one of economics and investment policy and has absolutely nothing to do with fast breeder reactor safety, plutonium hazards, nuclear weapons or environmental questions. The Wall Street banking community and its political arm, David Rockefellers' Trilateral Commission (which includes President Carter, Vice President Mondale as well as 20 of the Administration's cabinet and other high-ranking officials) are insisting that the New York banks' bulging portfolios of bad debt be refinanced at all costs in order for these banks to maintain nominal solvency and their enormous political and financial clout over the world's economy.

To accomplish this refinancing, they are diverting every possible penny of liquidity available in times past for new capital investment, food, agriculture, trade, etc., into debt repayment. While the public reads about the dangers of "nuclear terrorism," etc., the talk in lower Manhattan boardrooms is of the unjustifiable capital cost of fission development — an investment which power companies have found well worthwhile but that must now be sacrificed to keep David Rockefeller out of bankruptcy court. This fact is beginning to be admitted publicly, for instance in the just-released Ford Foundation report on energy which complains of the allegedly too high capital cost of fast breeder technology.

It is with these considerations in mind that one must view the Carter Administration's proposed Fiscal Year 1978 slash of $200 million from the Ford Administration's budget proposal for the federal Energy Research and Development Administration's (ERDA) Fast Breeder Program, a cut which actually would bring the 1978 authorization $30 million under the FY 77 budget.

The biggest Carter cut was in the Clinch River Breeder Reactor (CRBR) being built by Westinghouse and Burns and Roe, a vitally important 380 MWe demonstration power reactor. However, almost as important was the complete elimination of funds for designing of commercial size, fast breeder reactor power plants. Three commercial projects of this type had been underway for over a year now, by General Electric Co., Westinghouse Corp. and North American Rockwell's Atomics International, all in cooperation with the Electric Power Research Institute and ERDA. Similarly, the ERDA fusion budget was cut a full 20 percent across the board, or $80 million, to begin a process of scaling it down to a "low level program" to ensure that fusion will never be achieved.

What Is The Fast Breeder Reactor?

The Fast Breeder Reactor (FBR) is a more advanced, next generation nuclear fission power reactor that operates in principle in much the same way as current light water-cooled fission reactors (LWR). Two major differences in the fast breeder reactor are its much higher power density and its ability to actually create or "breed" more fissionable fuel than it burns up during its operative cycle. Its use of higher energy neutrons, in the range of 0.1 Mev (Million Electron Volts) to several Mev, for the fission process, permits a much more efficient use of these neutrons through an appropriate reactor core configuration. These high energy neutrons (*fast* neutrons) not only enable a compact reactor core design through the elimination of neutron moderating material, but also provide a large, high energy neutron leakage flux that escapes the core region and is eventually captured in the adjacent "breeding blanket" region. The fuel produced in this region can be used to refuel the reactor itself or to fuel additional FBRs or LWRs.

Because of the power densities of the FBR, which are on the order of 3 to 5 times greater than in LWRs, the heat transfer medium therefore must also be much more efficient in the FBR. That is, for comparable 1000 MWe generating units, the heat transfer rates, or more particularly the heat fluxes, must be roughly 3 to 5 times greater than in an LWR. This is accomplished by providing a more conductive reactor coolant, the most commonly used now being liquid metals and more usually liquid sodium. Other coolants have been suggested and in fact used in several designs, including high pressure, high velocity helium gas and high pressure, high velocity steam. However, because of the many technical and material advantages of liquid metals, the international fast breeder reactor community has converged on liquid sodium as the first choice of a coolant at this time. This has led to the labeling of the breeder reactor as the Liquid Metal Fast Breeder Reactor (LMFBR).

The procedure for removal of the heat generated in the reactor core and blanket region is relatively straightforward and similar in principle to that in LWRs or fossil fuel power plants. Heat is transferred via a primary sodium circuit to an intermediate sodium heat transfer circuit. It is then transferred from this intermediate circuit to the steam generator-turbine system where the heat energy is converted to mechanical energy in driving an electrical generator. This generator finally converts the energy to electricity which is fed into a utility company's power grid for transmission to consumers.

The blanket region of the FBR completely surrounds the active core region and is purposely designed to absorb as many escaping neutrons as possible. The blanket fuel material starts out as depleted uranium oxide (i.e., uranium in which the fissionable isotope U-235 has previously been almost entirely removed in the enrichment and manufacturing process for LWR fuel), but over several months and years time gradually builds up a fissionable plutonium concentration, Pu-239, through the breeding process. The process is as follows: The reactor core fuel material starts out as a mixture of approximately 20 percent Pu02 (mostly non-fissionable uranium). High energy neutrons are produced primarily from fissioning of Pu-239 and are absorbed in both the UO2 in the core and in the blanket regions as well as in fissioning of other plutonium atoms. Neutrons are also absorbed in control rods which are used to regulate the power level of the reactor. The capture of a high energy neutron in the nucleus of a U-238 atom results, through a decay chain, in the production of Pu-239, i.e. new usable fuel, in both the core and blanket region.

Both the core and blanket fuel is contained in bundles of closely packed rods, numbering from anywhere between 91 and 271 rods depending on the design. The rods are filled with small pellets of the oxide fuel material on the order of 0.3 inches in diameter. Several hundred core and blanket region bundles make up the reactor for a commercial size power plant. As the core region fuel burns up, usually over a two or three year period it is removed for reprocessing and new fuel is added. Likewise, as the blanket region material breeds plutonium and eventually reaches material design limitations, it too is removed from the reactor, at the same time as new blanket bundles are added, and shipped to the reprocessing plant where the newly bred fuel is extracted.

Breeding ratios for these plants must be greater than one, in order to generate more fuel than is burned, and will vary between 1.2 to 1.5 for first and second generation breeder reactors respectively. In terms of doubling time, a commonly used term for the time it takes to double the amount of fuel that was started with, these reactors will achieve values from a near-term of 30 years to less than 10 years for the more advanced fuels. In practical terms, this means that during the reactor's lifetime of 40 years, it will produce enough fuel for itself plus at least one more FBR of the same size, and eventually up to three and four additional reactors. Plutonium also makes an excellant fuel for LWR's and is clearly the solution to the eventual problem of the limited resources of uranium-235 from the worlds reserves of uranium ore.

Are There Problems With The Fast Breeder Reactor?

Most of the so-called safety and national security problems that have been associated with fission reactors and the fast breeder reactor in particular, are either pure fabrication or at best a deliberate exaggeration of litigious issues in order to play on the psychological fears of the ordinary citizen. In general, the same can be said of the technical problems associated with achieving a viable commercial fast breeder reactor, however since it is still considered to be a developing concept there are some practical engineering problems that must yet be solved.

Probably the most pressing technical problem that still needs a solution is that of the steam generator design for these plants. It is in this piece of equipment that a very thin (i.e., 0.10 inch) barrier between two extremely incompatable heat transfer fluids, liquid sodium and water, must be maintained. That is, if sodium and water get together, a rather turbulent reaction occurs in which sodium burns and hydrogen is produced. Therefore, the problem to solve is to design and fabricate very large steam generators that do not leak or that leak very rarely. This requires higher quality materials manufacturing, fabrication techniques, welding methods and quality assurance procedures than have heretofore ever been achieved in the heavy equipment industry. Although considerable progress has been made over the past several years, a viable commercial liquid metal steam generator is still not a reality. Prototypes of such units are (or at least were before Carter's announced cuts) being built and tested in the United States and elsewhere, particulary in France, which should produce solutions to this key problem area in the heat transfer chain.

Beyond this, although there are many engineering and technical details that must be worked out and tested throughout the FBR heat transfer, fuel handling and safety systems, there does not appear to be any problem that cannot be handled with a well-funded and well-planned development program. The breeder concept itself was first proven way back in 1951 when the very small Experimental Breeder Reactor-I (EBR-I) went into operation in Idaho. Since then, several other experimental breeder reactors and more recently prototype breeder power reactors have verified these results in several different countries. The materials and engineering problems associated with both the core and blanket fuel and structural components have been, for the most part solved, with testing of fuel in progress and-or planned in several countries. Furthermore, fuel handling systems, heat transfer systems and the systems for handling of liquid sodium are quite well established now and any additional "bugs" will be worked out in current or future prototype plants.

Most of the so-called safety issues have been thoroughly discussed and debunked by myself and others in previous articles* and will not be repeated again here. Suffice it to say that it has been thoroughly proven that a nuclear explosion is impossible in both LWRs and FBRs, and that any discussion to the contrary is either a lie or at best a product of abysmal ignorance. The safety of these reactors is absolutely guaranteed, even in the event of such an incredible, essentially zero-probability occurrence as a core meltdown.

The issue of the dangers of plutonium has similarly been clearly debunked and exposed as a "hoax." The source of this hoax, in fact, has been directly traced to those very financial interests who benefit from the current, artificially inflated uranium prices and who are trying to make sure that a cheaper replacement, i.e., plutonium, is not available to reactor owners. The question of refinancing of New York bank debt holdings through vastly increased oil and uranium prices, i.e. increases of three and five times present levels, is clearly involved in this issue.

Nuclear terrorism a la "five Palestinians and a shoebox filled with plutonium" is also a hoax, as are all alleged "backyard atom bomb" schemes. Nuclear terrorism could in reality only occur if a government handed over a nuclear explosive device, ready made, to a so-called "terrorist group."

Finally, the real facts of the "nuclear proliferation" issue, the breeder foes' last objection, are actually the opposite of their argument. Their alternative of depriving energy, and therefore development, to other countries by withholding nuclear power will in fact very likely provoke exactly what they say they are seeking to prevent, i.e. a nuclear war, as hungry energy-short nations battle one another for dwindling supplies of energy and other necessary goods. Providing a world environment for development through access to raw materials, energy, agricultural and industrial research for all countries will quickly eliminate the international environment associated with the "need" for nuclear weapons. Thus the diffusion of breeder and other peaceful uses of nuclear power will actually reduce the underlying causes of all forms of war.

The Role of the Breeder Reactor in the Transition to Fusion

Nuclear fission and particularly the Liquid Metal Fast Breeder reactor will play an extremely important role in the next 15-20 year period during which, scientists now predict, the world can make the transition to on-line fusion reactors as a primary energy source (provided there is adequate funding of the fusion program). There are three major reasons for this. First, the breeder will provide a significant amount of the high transitional period energy requirement for fusion development (approximately 25 to 30 percent) that cannot be supplied by oil, gas or coal. Secondly, it will provide a very important several year "energy safety margin" to cover any problematic delays or unforseen difficulties in achieving a viable fusion powered generating system. Third, the techniques and the skilled manpower associated with the liquid metal breeder reactor fuel systems, and the steam generators in particular, are absolutely essential for first generation fusion-fission hybrid reactors and-or pure fusion reactors.

A reasonably rapid rate of expansion (10-15 percent) of current state-of-the art LWR's will result in the depletion of the world's "reasonably assured uranium reserves" well before the end of this century. Although LWR's will generate some new fissionable plutonium, this amount will not be nearly sufficient to refuel an ever increasing number of LWR's. Therefore, fissionable plutonium fuel (and eventually Uranium-233 from naturally-occurring Thorium-232) must be produced in large quantities from first the fast breeder reactor and eventually the fusion-fission hybrid reactor in order to provide the fuel for even continued operation of the existing LWR's at that time. The fuel generating capability of LMFBR's and FFHR's will also provide a vast resource of fuel for the construction of more LWR's and LMFBR's during the transition period. This fuel production capability for fissionable materials can be either limited or expanded depending on the progress towards on-line fusion reactors and will cover any delays in the program.

In addition to energy and fuel, an extremely important contribution that the fast breeder is making and will continue to make during its development is that of advancing the technology needed for fusion power plants. This is especially true for the fusion-fission hybrid reactor since it is quite similar to the LMFBR, but it is also true for the first generation fusion plants which are likely to use various liquid metal systems. Therefore the continued development of the LMFBR and its skilled engineering cadre, and particularly of the difficult liquid metal sodium steam generator system is absolutely essential to the rapid development of fusion plants. As is well known by any competent engineer or technician, the engineering and development problems associated with large, advanced technology power plants are difficult and sometimes complicated. These problems and requirements for the development of fusion power will be considerably more challenging than any past project and therefore require all of the skilled manpower and technological capability that we can muster starting now.

The fusion-fission hybrid reactor, which will be fully described in a future article, is a system that combines the advantages of the liquid metal fast breeder reactor with those of a near-term fusion reactor, and achieves a potentially even more efficient nuclear power system. The advantages of high energy density and thermal efficiency are inherent in this system. In addition, however, the reactor efficiently employs its dense high-

*See "Plutonium Fuel: Safe...And Necessary" and " 'Nuclear Terrorism Threat' Is a Hoax" in *Stop Ralph Nader, The Nuclear Saboteur*, Campaigner Publications, 1977.

energy neutrons (from the deuterium-tritium fusion reaction) to produce large quantities of both fusion and fission fuel as well as nuclear energy. Fusion fuel — tritium — and fission fuel — plutonium — are produced as neutrons react with the lithium coolant and uranium blanket of the system respectively. The tritium is continuously used to fuel the fusion reaction of the hybrid reactor while enough plutonium is produced to fuel from six to ten large fission reactors. Therefore, as this technology eventually becomes available, it will be a better plutonium breeder than the fast breeder reactor.

The Current Status of Fast Breeder Reactor Development

It is well established throughout the international nuclear community that France has the unchallenged lead in the development of the Liquid Metal Fast Breeder Reactor and in fact could probably start committing resources to large-scale construction of its Superphoenix design at locations throughout the world (including the U.S.) in the *early 1980s*. France in combination with a consortium of major European electric-utility companies, last fall made a commitment to start construction of the first Superphoenix power plant, a large 1200 MWe commercial LMFBR. Expected completion and operation of this power plant is scheduled for 1985. The Superphoenix design will be based to as large an extent as possible on the design of the smaller 250 MWe Phoenix demonstration plant, which completed its first two years of successful operation last summer. Again, such performance by an LMFBR demonstration plant of this size has only been achieved by France.

Although the French achievements in this area are the most heralded, several other countries, including the U.S., Soviet Union, Great Britain, Germany, Japan, India, Italy and a few others have major and significant efforts underway for the FBR. All programs characterized by first the construction of a medium-size (200-400 MWe) demonstration plant, followed by a full-size commercial power reactor a few years later. Great Britain probably has the second most advanced fast breeder reactor program with the completion of their 250 MWe Prototype Fast Reactor about two years ago. This reactor, however, has not yet been run at full power because of difficulties experienced with the steam generating equipment.

A similar situation exists in the Soviet Union with their 350 MWe demonstration plant, BN-350. However the steam generator problems have plagued them even longer. The steam generator problems in the Soviet Union have been primarily caused by poor welding techniques and quality control measures, while in Great Britain they have resulted from a few bad welds and faulty sodium purification and start-up procedures.

The effort in the U.S., although off to an early start in 1951 with EBR-I, the Fermi Fast Breeder Reactor start-up in 1965, the Experimental Breeder Reactor-II (EBR-II) start-up in 1967, and the Southwest Experimental Fast Oxide Reactor start-up in 1968, has since lagged considerably. These four reactors were essentially small-sized fast reactors (from 2 to 60 MWe), although two had steam generators and turbine generators incorporated in the plants and produced some electricity. The U.S. is currently well along towards the completion of another fast flux test reactor (FFTR), scheduled for start-up in 1978, but again this is primarily a fuel element test facility and not a proto-type power reactor.

The U.S. demonstration plant project, the 380 MWe Clinch River Breeder Reactor (CRBR), is just getting off the ground — site work is just beginning — but is currently threatened with further costly delays and probable cancellation by the Carter Administration's anti-nuclear power policies. With this anti-development position taken by the Administration, a commercial sized breeder reactor is way out of the picture and, as mentioned earlier, the funding for designing studies for such plants was just cancelled by the President.

In sum, it is clear, particularly from the French experience as well as other countries', that a viable LMFBR commercial power plant is assured and is simply a matter of a continued development commitment. With France, Germany and Great Britain already exporting light water or gas-cooled reactors and rapidly developing a capacity to export fast breeder reactors in the near future, the Carter Administration's anti-breeder campaign seems likely to give the U.S. another black eye among its once-closest allies, while possibly freezing qualified U.S. companies out of a major international market.

— Jon Gilbertson