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THE ENVIRONMENTAL AND REGULATORY ASPECTS OF THE BREEDER REACTOR

By William O. Doub*

On January 14, 1972, in Washington, D.C., the Chairman of the Atomic Energy Commission (AEC), Dr. James R. Schlesinger, announced that the Commission had accepted, "as a basis for detailed negotiation, a joint proposal of the Commonwealth Edison Company of Chicago and the Tennessee Valley Authority for the construction and operation of the nation's first demonstration liquid metal fast breeder reactor plant." The plant, a joint industry-Government effort, is to be built in Eastern Tennessee at a specific location still to be designated. Work was scheduled to begin within the year. The plant is expected to go on the line by 1980.

Nationwide attention had been focused on the breeder reactor as a result of the President's Energy Message to Congress on June 4, 1971. In that message he stated: "Our best hope today for meeting the Nation's growing demand for economical clean energy lies with the fast breeder reactor." Further public interest in the breeder was generated by the President's statement at Hanford, Washington, on September 26, 1971, when he stated he would request authorization for a second demonstration breeder plant.

Undoubtedly administration support had considerable bearing on the financial pledges made by the utilities of this country to the demonstration plant program. Pledges from privately-owned and publicly-owned utilities total about $240 million. Together, the President's statements and industry pledges led to the announcement that this Nation will indeed bring the fast breeder reactor to commercial fruition, a goal which many in the nuclear field have so long believed to be necessary.

WHY THE BREEDER

At this point a question may arise—one which to many is not merely rhetorical—namely, why the need for the breeder reactor?
To answer this it is necessary to explain the principle of the breeder. Basically it is a nuclear system that uses its fissionable fuel both to produce power and to provide excess neutrons to transmute non-fissionable material into new fissionable fuel. In the case of the liquid metal-cooled fast breeder reactor (LMFBR), the fuel, fissionable plutonium-239, will be the source of power at the same time that neutrons excess to the fission process bombard a blanket of non-fissionable uranium-238 and transmute it to more plutonium-239. This new plutonium can then be recycled into the same reactor or used to fuel another reactor. A fast breeder, such as the LMFBR, is projected to be able to breed enough new fuel to refuel itself and one equivalent size reactor in a period of about 7-10 years. This is known as its "doubling time." Coincidentally, this is considered a good "doubling time" because it roughly parallels the time of the doubling of electricity demand in the U.S. over recent decades.

Among the foremost reasons for development and eventual commercialization of breeder reactors is the fact that the breeder, with its highly efficient use of nuclear fuel, particularly plutonium, can extend the life of our known natural uranium fuel supply beyond the next few centuries. With the Nation's electrical generating capacity expected by many to reach over two billion kilowatts in the year 2000, a reliable and abundant relatively low cost source of electricity cannot be reasonably assumed without the breeder. Even if the per capita energy consumption growth rate should be less than presently anticipated, our overall energy needs will continue to increase in the years ahead if we are going to satisfy the needs of an expanding population and to achieve the social goals generally accepted today. The issue as to whether our society, for environmental or other reasons, ought not to curb its appetite for energy and for electric power is, I personally believe, a legitimate social question. We believe, however, that it is inappropriate for the AEC to take a position on this issue, and accordingly we remain a neutral, albeit interested, observer.

The breeder, while providing a virtually limitless supply of economic electricity, will also provide an enormous potential for the use of electricity to clean up our environment. The breeder itself can be made virtually pollution-free. Further, its high plant thermal efficiency will lessen some of the thermal effects problems. Importantly, the breeder—by converting non-fissionable uranium-238 to fissionable plutonium—will most efficiently use our nuclear
fuel resources. In addition, it will provide a premium market for plutonium produced by the more conventional light water reactors now in operation or being built.

The concept of the breeder is not new. Dating back almost to time of the first nuclear reactor, work on the breeder concept was initiated experimentally in the mid-1940s. The work was continued in the following years by the AEC's national laboratories on a scale sufficient to demonstrate its technology and basic safety characteristics. This period paved the way for the development of test facilities, such as the Experimental Breeder Reactor II (EBR-II) in the State of Idaho, and the privately-owned Enrico Fermi Atomic Power Plant in Michigan, both of which first operated in 1963.

Although early fast breeder developmental efforts in the '50s and early '60s were promising, certain technological problems caused delay in that development; attention then turned to the light water reactor, with respect to which there existed readily available technology and broader experience. The level of breeder development then was such as to preclude commercial demonstration. Particularly lacking were the strong quality assurance and disciplined engineering practices needed to construct and operate safe, reliable and economical breeders. The resolution of remaining technological and engineering problems continues to be of paramount importance to this Nation and to any nation which foresees a dependence upon the utilization and operational reliability of breeder electric power plants.

Of continuing concern has been the industrial commitment necessary to the development of a self-sustaining competitive breeder business. Thus, to meet the objectives of the Nation's Civilian Nuclear Power Program in a timely and successful manner, it has been necessary for the AEC to review, augment, and strengthen each of the many elements of the LMFBR program. This has been accomplished in large part since 1965, but much work remains to be done.

**Status of the Commission LMFBR Program**

Apart from this historical resume, where in fact does the LMFBR program stand today? We must begin building a demonstration breeder plant promptly if we are to meet the commitment in the President's energy program to demonstrate the LMFBR by
1980. Toward this end, we have been actively involved over the past year in project definition activities. Among the beneficial results of these efforts has been a better appreciation of the magnitude, complexity and implications of the demonstration plant program by the many organizations involved.

Regarding funds, the AEC has been granted legislative authorization to participate in the first LMFBR demonstration plant. As a result of the President's message and the recent actions by the Congress, an additional $50 million for the demonstration plant has been authorized. This brings the total direct cash contribution by the Government up to $100 million. Also, the level and type of support which can be provided by the LMFBR base program has been increased significantly as a result of Congressman Hosmer's amendment to the AEC Fiscal Year 1972 authorization bill. His amendment removed the $20 million financial limitation on the Government's direct R&D contribution and allowed for significant additional use of the LMFBR base program in terms of development, services, and facilities, up to a ceiling of 50 percent of the estimated capital cost of the first demonstration plant.

Also during the past year, a Senior Utility Steering Committee and a Senior Utility Technical Advisory Panel, composed of top management representatives from both privately and publicly owned utilities, have been working closely with the AEC in developing means of promptly proceeding with the demonstration plant program. It was the success of this work that led to the final arrangements for the first LMFBR demonstration plant announced in Washington last January. Now that the arrangements for this plant are settled, we will explore the options for the timing and financing of a second demonstration plant.

The LMFBR demonstration plant program plans have taken advantage of the experiences of the AEC's and industry's light water reactor demonstration program, wherein a series of demonstration plants (Shippingport, Yankee, Big Rock Point, San Onofre, La Crosse, Pathfinder, Elk River, Bonus, Haddam Neck) culminated in the unprecedented orders now on the books. The basic LMFBR program plans originally identified up to three demonstration plants as necessary to obtain a sufficiently strong technical and industrial base for a national program of this high priority. The plans included startups spaced at two-year intervals.

Of considerable interest are what might be termed LMFBR support facilities. The experience from existing facilities and the light
water reactor program is being factored into the design and construction of the 400 megawatt (thermal) Fast Flux Test Facility (FFTF) at Hanford, Washington. This reactor will be the primary irradiation facility for testing many components of the breeder under actual operating conditions. It will generate no electrical power but it will play a vital role in the LMFBR program as a vehicle for consolidating and unifying the U.S. breeder program, which consists of the operation of a variety of test facilities in different parts of the country. The FFTF is well advanced, on-site construction at Hanford is in progress, and fabrication of its major components is under way. Through its design and development, the FFTF is already contributing directly to advancing breeder component and system technology and developing the industrial capability required for demonstration and commercial breeder plants. The Senior Utility Technical Advisory Panel, in its tour of the Hanford Engineering Development Laboratory, noted the excellent team work in carrying out the plans for the engineering effort on the FFTF and was impressed with the large number of extensive new engineering facilities being built at Hanford for the overall LMFBR program.

Breeder Development and the Future

I am encouraged about the developmental future of the breeder, and I believe there is credible evidence for my optimism. For one thing, there is an increasing maturity in all nuclear energy programs and a widening recognition that the rigid discipline required to develop the technology of the breeder is a reasonable price to pay considering the potential benefits.

The cost of the breeder has not and will not be inexpensive. Continued substantial investments of dollars and personnel resources will be required to assure the successful development and commercial availability of the LMFBR by the mid-1980s. It has been estimated that to meet the electricity demand for the year 2000 will require the construction of over 1000 one million kilowatt plants, of which several hundred very well could be breeders. Should the breeder become a member of the Nation’s energy team, there could be capital savings in uranium enrichment plants, in uranium mining and associated industries, and in the fossil fuel industry, and savings in nuclear fuel cycle costs.

Major energy programs such as the breeder project require large
long-term commitments of many types of resources now in short supply. The attendant high initial costs, particularly for the demonstration phase with its associated uncertainties, impose special problems requiring close coordination between the Federal Government, which provides a large share of the funding, and the energy industry. It appears that in the case of the first demonstration plant, the voluntary contribution approach, along with Government support, will successfully meet financial requirements for plant commitment. The financing of the second demonstration plant should also benefit from this approach.

The success of the demonstration plants and their eventual commercial introduction depends on industry's participation in planning, decision-making, program management, financing, and leadership. Key staff members of the utilities, as well as young recruits, could be assigned to the various participating AEC laboratories, nuclear steam system suppliers, and other contractors. Their interest, support, and active participation will be solicited and urgently needed.

Environmental Impact of the Breeder

Of increasing interest is the question of the impact of the breeder on our environment. One of the objectives in the development of the breeder is to virtually eliminate air pollution from electric power plants. Achieving this objective will carry out the President's intent. He directed the AEC to insure that new breeder plants are designed in a way that prevents discharge of radioactivity to the environment from the plants' effluent systems. This can be accomplished by containing the radioactive waste products within restricted confines of the fuel cladding, the reactor, and the waste disposal systems.

While the record to date has been good, additional research and development efforts are necessary to better understand the exact nature of the processes involved in the removal and storage of waste and other unwanted products, so that full advantage can be taken of inherent features of the breeder to contain radioactive waste products. With regard to the waste heat rejection problem, the higher thermal efficiencies of breeders such as the LMFBR mean less waste heat discharged to the environment in the steam cycle part of the system, and, of course, breeders will thereby reduce the thermal impact of nuclear plants on the environment.
In order to determine the possible environmental consequences of nuclear power we are looking not only into the immediate future but also 50 years beyond. As an example, for the past year the AEC has been working on a projection of the environmental impact of nuclear power through the year 2000. In this regard, we are conducting a comprehensive analysis of the entire Mississippi watershed above the confluence of the Ohio River, together with the lower Missouri basin. It is estimated that this area in the year 2000 could contain about 30 million people with an electric generating capacity of 250,000 megawatts, of which well over half could be nuclear. Analysis such as this provides guidance to the AEC in developing reactor programs as well as a base for future plans, such as those pertaining to nuclear power plant siting, plant design, licensing and regulation, operation, and maintenance.

The LMFBR's vast saving of natural resources and the resulting reduction of environmental impact, is indeed significant. If the commercial breeder can be introduced in the mid-1980s, as we hope it will, by the end of this century we may see its wide-scale use, replacing the annual consumption of hundreds of millions of tons of coal. Even though the Nation is counting on vast improvements by then in the way that coal is mined, transported, and burned, for the many plants that will still need to rely on coal, the reduction in environmental impact resulting from the replacement of large amounts of coal by the breeder should be highly beneficial. For example, some of the environmental gains the breeder could effect by the year 2000 are: the elimination of the movement of approximately three million railroad carloads of coal per year (not to mention the air pollution from the burning of that coal), the reduction of land area for power plant use of some 200 to 300 square miles, and the elimination of the need for additional thousands of acres of storage area for ash.

Viewing the situation more positively, one may expect that the use of a combination of (1) nuclear breeders, (2) fossil plants burning gas produced by coal gasification via nuclear heat, (3) industrial processes using electricity (electric furnaces, electrolysis, etc.), and (4) electric powered transport could substantially reduce, and perhaps virtually eliminate, air pollution from non-mobile energy sources across the country. This is not merely wishful thinking but a genuine possibility—if we are willing to pursue new technologies, many of which are already clearly feasible and some of which could soon be perfected. The breeder, of course, should have
a high priority among these technologies, since only through it will we be able to provide the large part of the electricity essential to the success of this environmentally protective approach.

Why is this true? The breeder, as mentioned, extends the use of our natural uranium supply from decades to perhaps thousands of years. As it does so it will offer many more immediate fuel advantages. It will create a market for the depleted uranium produced by today's enrichment plants. Eventually, with its own huge electrical energy demands, it will all but eliminate the necessity for uranium enrichment. It will also make use of the plutonium that will be produced in present and future light water reactors. It has been estimated that about 50 percent of all plutonium to be produced in the next 30 years will come from light water reactors. This may well amount to thousands of tons of plutonium. Some of this plutonium will be recycled into the light water reactors but most of it may be utilized to fuel future breeders.

SAFETY AND THE BREEDER

We have considered the environmental impact of the routine operation of the breeder reactor and its associated fuel cycle. A closely related consideration is the safety of the breeder. The potential hazard of radioactive releases is, of course, obvious. It is necessarily required that designers, fabricators, utility operators, and regulatory and safety boards be convinced that the public will not be exposed to undue risk associated with equipment malfunctions or other abnormal conditions, including postulated accident conditions.

The utility industry must acquire a thorough knowledge and understanding of the behavior of the fuel in the event of fuel failure and damage to the reactor core, as well as accidents and failures in critical parts of the reactor plant. This knowledge and understanding must then be applied to what the Commission calls a "defense-in-depth" technique, consisting of three basic principles:

(1) achieving superior quality in design, construction, and operation;
(2) providing for accident detection, prevention, and mitigation using safety features which would eliminate or reduce the occurrences of accidents; and
(3) as a final measure of assurance, making provision for conse-
quence-limiting safety features including containment of any radioactive products.

Experience indicates that the "defense-in-depth" concept greatly augments applied reactor safety and, if conscientiously implemented, will provide the assurance needed for the safe, reliable, and economical operation of breeders. More than two decades of orderly reactor development have demonstrated that nuclear power plants can be built on a repetitive basis to operate safely, reliably, and economically. The breeder safety and reliability program is designed to maintain this record.

Two of the most controversial aspects of fast breeder safety are the management of plutonium and the management of sodium. Considering the fact that over 50 percent of all the plutonium to be produced in the next 20 years will come from the light water reactors, one can understand that the proper handling and containment of plutonium throughout the entire fuel cycle is a problem common to both the light water reactor and the breeder. The AEC from its beginning has been committed to studying the toxicity and other potentially hazardous properties of plutonium. It is crystal clear that they require careful and systematic control practices and continuous review of and improvement in such practices.

Of considerable concern is the use of sodium as a coolant. Its excellent heat transfer properties, including a high boiling point, provide an inherent capability of emergency cooling with relatively simple cooling systems. However, large-scale application of sodium technology requires that design provisions must be made to cope with problems associated with sodium chemical activity, neutron-induced radioactivity, and non-transparency. Over 20 years of sodium use in reactors and test facilities in this country and abroad clearly indicate that such problems can be resolved.

REGULATION OF THE BREEDER

In any "state-of-the-art" review of the breeder there arises the question of its impact on regulation. As a general rule, it would presently appear that many criteria that have been issued by the AEC as part of its regulatory responsibility are to a degree applicable to breeder nuclear power plants.

There is no question that detailed safety reviews of complex breeder reactors will concern themselves with technological aspects
different in specifics from those considered in licensing water or gas-cooled thermal reactors, though basically the same in principle. These detailed reviews could seriously affect the licensing process if advantage is not taken of what we now know and are doing, and of adequate lead time to solve problems. For example, this country already has considerable breeder experience: eight years of operation of EBR II; the licensing and operation of the Fermi breeder reactor; the licensing and operation of SEFOR as well as Hallam (a sodium-cooled graphite moderated thermal reactor); and the several years of design and construction for the FFTF at Hanford and the associated in-depth safety reviews.

The Commission, in the public interest, is held accountable for its policies and decisions. The constant reconciliation of conflicting interests is a difficult task requiring painstaking judgments to achieve the proper balance between the increasing demand for energy and the preservation of our environment. In this process the AEC has a clear responsibility to direct each aspect of the licensing procedure so that units are not delayed by conflicting and overlapping procedures or unclear guidelines, and that court decisions and legislative actions are implemented in a prompt and equitable manner. It is clear that unnecessary regulatory delays must be promptly eliminated. The time between the filing of an application and the granting of a construction permit or operating license has been increasing in recent years on the average of over 20% annually. These delays are untenable. At the Annual Conference of the Atomic Industrial Forum held in October 1971, I discussed corrective action that the Commission is taking to reduce delays, and actions, which if taken by utilities and environmentalists, might contribute significantly to reducing delays. Many of these procedural changes have been implemented in the intervening time.

It is clear that there is a national sentiment to increase accountability for environmental consequences of proposed nuclear power plants, although these consequences are to be balanced against other essential considerations at the national, state, and local level. Advanced planning and wider responsible public participation in the preliminary planning process are necessary to effectuate this accountability in the licensing and regulating of all nuclear power plants, including the breeder.
CONCLUSION

There is a growing awareness that the breeder as a viable energy alternative can also contribute significantly to the solution of many environmental problems associated with the generation of electric power. It is not surprising that other major nations have also selected the LMFBR as their future power source and are proceeding along the same path. We believe that the deliberate, well-planned course of action we are now embarked upon will prove to be successful. The announcement by President Nixon on September 26 of his support for a second demonstration plant, along with his actions prior to that time, is a clear sign that this Nation does not intend to lag behind.

The effective licensing and regulation of breeders are essential to public acceptance of nuclear power. The development of the breeder, with its inherent environmental and other advantages, aided by the experience derived from the licensing, regulation, and operation experience of thermal reactors, should enable us to assure the Nation that it will have a most attractive and practicable alternative to other presently available energy sources when the need arises.

Footnotes

* Commissioner, United States Atomic Energy Commission.
5 Id.
8 G. T. Seaborg, supra note 6.


See supra note 3.


Id.

Id.


Id.

Id.


Id.

Id.

See G. T. Seaborg, supra note 6.


Id.


Draft Environmental Statement, supra note 26.

Id.


