XA8007181

International
Nuclear
Fuel
Cycle
Evaluation

INFCE

INFCE/DEP/WG.5/16

U.S. CONTRIBUTION OF SECTION A.3. THE SIGNIFICANCE OF LONG-TERM SUPPLY AND ENERGY SUFFICIENCY PROSPECTS OFFERED BY FAST BREEDERS

U.S. CONTRIBUTION OF

SECTION A.3 THE SIGNIFICANCE OF LONG-TERM SUPPLY AND ENERGY SUFFICIENCY PROSPECTS OFFERED BY FAST BREEDERS

OCTOBER 28, 1978

A.3 SIGNIFICANCE OF LONG-TERM SUPPLY AND ENERGY SUFFICIENCY PROSPECTS OFFERED BY FAST BREEDERS

Given that human social and economic goals do not change in the twenty first century, and given that there is no technological break-through rendering obsolete the use of electricity as a form of energy, the development and use of new technologies for electric generating systems will be neded. This need will stem from increased supply needs as developing countries progress and industrial countries continue to grow as well. Economic pressures to keep electricity costs low will be present and will be reinforced by the inability of current systems to meet the future need in acceptable ways. Environmental concerns will play an increasingly important role, and national energy security needs will continue to be seen as very important in the affairs of most countries.

The time required for engineering development of major new technologies and significant installation of them together with their supporting systems is measured in decades. Further, there is not one new technology for electricity generation that will be developed, but several. Some of these may well be smaller and more dispersed in basic concept than the current large plant-large grid approach. However, large central station electric power plants will be the best solution in many situations.

Important among these technologies now under development in several countries is the fast breeder reactor. The potential benefits of breeder reactors flow from the following characteristics:

1) They offer the potential for orders of magnitude increase in efficiency in use of the world's uranium supply over the converter reactors currently being developed;

2) They would build on the existing thermal reactor and fuel cycle technology;

3) They hold the long-term possibility of national nuclear fuel supply independence;

4) Given careful design, operation and regulation, they would be environmentally similar to thermal nuclear power systems;

5) Their development is quite far advanced in a few countries so that implementation in those countries could begin in the next decade.

However, there are costs involved in breeder deployment which must be balanced against the potential benefits in any national decision to proceed from thermal nuclear power to breeders as part of an electrical system.* Such a decision ought logically to depend on a number of factors: the cost compared with feasible alternative means of generating electric power; the

*Described more fully in the U.S. Reference Paper on National Decisions on Breeder Development and Deployment.

importance attached to energy independence and the degree to which a breeder program can help in the realization of that objective in the time scale of interest; and on other effects not captured in the usual economic analysis, including the nation's capability to achieve various degrees of breeder program implementation.

Breeder and Converter Reactor System Cost Comparisons

Four factors are key in comparing breeder economics with LWR economics:

1) Capital Costs - higher for breeders

2) Fuel Cycle Costs - perhaps lower for breeders, heavily dependent on uranium price and full cycle facility capital cost.

3) Research and Development Costs - additional work needed to implement breeders above that needed for converters, depending on degree of independence desired.

4) Discount Rates - total costs of either breeders or additional converter reactors will depend on the cost of borrowed money.

An example calculation shows that uranium costs which would make the economic choice between converters and breeders a matter of indifference might vary from about 105 to 130 dollars per pound, depending on the discount rate applicable without RD&D expenditures. Alternatively, the indifference might vary from 150 to 600 dollars per pound depending on the discount rate and the level of RD&D expenditures undertaken to support breeder deployment for a program to add a 1 GWe plant per year over a period of 30 years.

Energy Independence

The scope for reducing energy dependence through breeder reactors is limited, of course, by the size of the nation's actual or potential electrical energy needs and grid capacity relative to its total energy requirements, since at present it is primarily in the electrical sector that the possibility of substituting nuclear for imported nonnuclear fuel exists. Successful implementation of a breeder economy would not grant any country total energy independence, but would provide relative independence from external sources of fuel for electricity generation by large plants. (For illustrative purposes, it may be noted that fuel for such plants currently accounts for between 5% and 15% of energy imports in the larger industrialized countries.)

The contribution of a breeder reactor program to national energy independence must be considered from the standpoint not only of fuel supply but also in terms of the technology and services associated with a breeder economy. To the extent that independence is a dominant objective, breeder deployment would be attempted with a minimum of reliance on outside support, which would lengthen the time before breeder deployment is started by demanding a higher level of domestic capability. In addition, complete nuclear autonomy requires eventual commitment to the entire fast breeder fuel cycle (reprocessing, fabrication, and waste management) and in turn a commitment to a substantial number of such reactors.

From an economic and technical perspective, the most realistic choice would normally be to follow a course of international cooperative development, or to initially import at least the nuclear steam supply systems (and perhaps much of the entire plant) as well as the needed fuel cycle services. With time, and through licensing arrangements, it may be possible to increase the fraction of design, manufacturing, and construction that can be carried out indigenously. This path is likely to be attractive only for countries with substantial demand and industrial capability.

With respect to reprocessing, nations deploying breeders at a moderate rate may elect to cooperate with or rely on others to reprocess spent fuel from both their converter reactors and breeders, and possibly to fabricate new fuel as well. There may be an economic advantage to this choice, particularly as regards smaller programs, because of the economies of scale. The capacity of what is likely to become the optimum size commercial reprocessing plant will probably be around 1500 tons of heavy metal per year, sufficient to handle the spent fuel from about 30 to 50 1000 MW(e) breeder reactors, and therefore much larger than will be required in the case of many countries.

As a final consideration, the relevance of industrial and manpower infrastructures to an independent breeder program should be addressed.* In the long-term, it may be possible to provide the necessary inputs to an independent or partially independent breeder program through investment in personnel training, the development of necessary manufacturing industry, etc. However, in the short and medium term, a breeder program may be an unrealistic option for some nations because of shortages of particular skills or other necessary inputs, or it may compete with other programs for resources in critically short, and not easily expandable, supply.

Proliferation Risks

A breeder reactor system, together with its fuel cycle system does involve significant quantities of material of potential nuclear weapons use. Another consideration in the decision to deploy breeders would be the cost, complexity and reliability of the international safeguards and other measures necessary to achieve reduction of the proliferation risks associated with this material to levels of international acceptability.**

*A useful discussion of the infrastructure problem in regard to nuclear programs generally is continued in Doc. Cochairmen/WG. 3/21, Evaluation and Definition Within the Scope of INFCE of the Specific Conditions in the Needs of the Developing Countries prepared by the IAEA.

**See discussions in reports of Sub-groups 5B and 5C.

Summary

There are potential benefits to be derived from the application of fast breeders for electric power generation in the future; there are also significant costs and other factors requiring consideration. Careful country-specific analysis is needed in decisions as to whether and when breeders are a good choice for application in any energy supply system.