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BREEDER REACTOR FUEL REPROCESSING

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To Be Presented To the
Conference on "The Future of Nuclear Power"
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Above all other considerations, I would place longer term planning and continuity of programs for nuclear energy as a most important element. This is particularly true for the breeder reactor and fuel reprocessing to which my present comments are directed as well as for radioactive waste.

When we consider the incentives for breeder reactors in the United States and the world, a clear overall need is difficult to foresee before the decade 2020-2030. It could come later or a little earlier. However, for some countries with large energy import requirements there is incentive for earlier deployment. If breeder reactors are required in large numbers and for rapid deployment, the technology, standardized designs, and construction and operating experience should all be in hand and adequate. I address the breeder reactor as well as reprocessing and refabrication because in the long-term one technology cannot exist without the other. Also the time frame of thirty to forty years is much beyond the normal effective planning time for the U.S. and in fact for most, if not all, countries.

At the time when uranium fuel resources and fossil fuels are becoming seriously depleted, breeder reactors could be required in large numbers and for rapid deployment. Under such circumstances, the technology, standardized designs, and construction and operating experience must all be in hand and adequate.

Standardization for the reactor is essential to minimize cost and to ensure reliability. This requires adequate experience, the development of standards and the existence of a developed industry. On the negative side, standardization invites repetition of mistakes or inherent weaknesses unless the systems have been well proven. This reinforces the need for a fully developed technology. Standardization for the fuel reprocessing and refabrication plants is less important because there would be many fewer such units, but the reliability requirements would be equally as high as those for the reactors. These considerations alone suggest that the building of experience through breeder projects, such as Monjue, Clinch River and SNR 300 are timely today as are some small reprocessing facilities. The next step, deployment of prototype demonstration units such as Super Phenix, should follow in timely succession.

Now I will address fuel reprocessing. The Oak Ridge National Laboratory has the lead role for the United States in reprocessing technology development. In this capacity we have chosen several objectives for future plant design. Foremost among these are:

Reduced Radiation Exposure to Workers
Near Total Recycle of Process Streams witn Minimal Environmental Impact
Plant Operation and Maintenance through Remote Systems
Improved Accountability
Resistance to Plutonium Diversion

These objectives lead to the design of a plant with totally remcte operation including sampling and maintenance. The operator would have no hands-on access to the fissile material which is fully protected at all times. The specification calls for all active effluents from the plant to be reduced to the solid state and be subject to controlled removal. Thus, the process cells would be essentially impenetrable except for airlocks to admit spent fuel and to remove product and waste.

The key for success with such designs is in the location and arrangement of equipment with operation and maintenance in mind. This concept is not unlike the conventional "canyon" designs, but operation in a totally closed cell requires new designs. Highly developed manipulators operating from a center aisle will have excellent access to equipment mounted on the walls. Removable racks are utilized for component support, thus further facilitating modification or repair. New manipulator designs provide the operator with force feed-back sensitivity and variable force control to facilitate both operation and maintenance. Sampling for analytical purposes also is by robot with only sample size quantities removable. Greatly improved remote TV type viewing systems complete the system. Such concepts when applied to both fuel reprocessing and fuel fabrication facilities provide diversion control for fissile materials from the irradiated fuel to finished fuel elements for which accountability can be maintained.

Proliferation is not subject to control by technology. However, this design concept, if applied within appropriate institutional arrangements, can be effective with respect to any given plant. This is possible through coupling the observers station to the electronic systems which couple the operator with visual systems, the manipulator and process units. This capability makes possible continuous observation and monitoring of the process at every step by a team of international inspectors. Any unauthorized modification of the process could be detected and reported for appropriate action.

Obviously the use of such technological development depends on their economic viability. Fuel reprocessing plants require very large capital investments. Thus, there is incentive to design for a long lifetime with replaceable internals. The plants also involve a minimum operating cost regardless of size. These factors provide incentive to build large-scale plants, ultimately perhaps five to even twenty tons of fuel per day. A 1000 MWe breeder reactor would discharge only 20 tons per year. Institutional arrangements must be made to provide an adequate fuel reprocessing load to achieve large plant sizes with an adequately developed technology. This requires planning for the build-up of breeder reactors and the fuel recycle system together. For smaller nations it may always be necessary to utilize regional recycle centers.

Since even small demonstration scale plants for fuel reprocessing and refabrication could serve more reactors than may be built in one country, there is merit in considering international arrangements, at least during the LMFBR buildup phase. Beyond that, the experience so gained might provide a base of cooperative arrangements to enable the extended use of multinational plants for better safeguards, to discourage proliferation, and to obtain improved economics.

It is very difficult to project the schedule for deployment of fast breeder reactors. However, as suggested afore, it is perhaps reasonable to assume that for the U.S. a need may exist for large-scale and rapid deployment by approximately 2020. If so, what should be done today? Light water reactor and Gas-Cooled Reactor experience suggests that indeed there is great advantage in standardization. Our French friends illustrate that advantage particularly well in their deployment of pressurized water reactors. There is no comparable experience for fuel reprocessing and the needs are different since relatively few plants are required. However, the potentially large number of breeder reactors and the size and cost of reprocessing plants suggest strongly that each should be fully developed and based on a large body of experience before being deployed widely or relied upon heavily.

For the U.S., completion of the Clinch River Breeder Reactor by 1990 and a first full-scale demonstration perhaps by 2005, followed by two to four prototypes in the period 2010 to 2020, would provide no more than a minimum base of experience for extensive reliance on breeder reactors. Similarly, experience with a small demonstration fuel recycle plant to utilize fuel from the Fast-Flux Test Facility and the CRBR followed by a plant of modest size in perhaps the year 2010 might be reasonable considering only the breeder reactor fuel cycle.

Finally, LWR fuel must be reprocessed and refabricated to obtain the initial plutonium for breeder reactors. Although the technology differs substantially because of differences in plutonium concentration and in the levels of fission product activity, the design principles set forth for breeder fuel recycle plants also can be applied to LWR plants. Much of the experience would, in return, be applicable to the breeder reactor fuel cycle technology. It is difficult to project the need and schedule for LWR fuel reprocessing because they are dependent on many factors, including the breeder reactor schedule, utilization of plutonium in the LWR and the costs and problems with continued fuel element storage.

The High Temperature Gas Cooled Reactor (HTR) would benefit substantially from fuel recycle, since it operates more efficiently on the thorium uranium-233 fuel. The HTR is viable on a once-through fuel cycle, however, it becomes more attractive with recycle. A principal disadvantage has been the cost of developing the fuel reprocessing and remote refabrication technology for the uranium-233 cycle. The inevitable buildup of highly radioactive daughters from the uranium-232 component necessitates that the system be remotely maintained and operated. The technology developed for the breeder reactor could make the U-233 HTGR cycle quite viable and of reasonable cost.

In summary, the time cycle for breeder reactor development and deployment is longer than the planning horizons for most private industry and governments. The potential advantage and possible desperate need for widely deployed breeder reactors in the future seem to dictate that suitable long-term development and deployment programs be established to provide an adequate base of technology and in time to meet the need. The problems of failing to do so and being confronted with a major requirement for nuclear energy could result in very serious economic and social disruption. The cost of maintaining the needed program, although substantial, is certainly modest compared with the potential problems which could ensue should we fail to proceed.