C. INTRODUCTION

Under the Atomic Energy Commission, nuclear power enjoyed substantial funding compared to that available for alternative energy sources. Though the existence of ERDA is expected to bring about a more appropriate balance, the need for nuclear power has never been greater, and many problems remain. Research and development to find solutions to these problems may require expansions in what is still by far the biggest part of ERDA's budget. The major issues in fission, fusion, and supporting technologies are discussed here. More detailed discussions of the nuclear program elements are given in the issue papers,

1. Converter Reactors

Light-Water Reactors. Light-water reactors (LWR's) now supply about 8 percent of the national electric energy needs (or 2 percent of all energy), and they will almost certainly dominate the nuclear industry for the next 2 decades. The reactor technology is well in hand, but many problems still exist, as evidenced by rapidly increasing costs and long leadtimes. These, in conjunction with the capital squeeze and power demand reduction, have caused the recent plant deferrals and cancellations. Nevertheless, the ERDA-48 Scenario 111 goal of 225 reactors by 1985 could be attainable if financing, licensing and manpower constraints are reduced, since that number of reactors have already been built or ordered. The projected plant startup rate in the remainder of the century, although twice that of the 1975-85 decade, still averages only to the number of plants (35) that were ordered in 1973. The primary obstacles to achieving either goal appear to be financial and institutional, not technological.

The cost and leadtime problems could be substantially alleviated if design, construction, and licensing techniques were improved. ERDA's new program addresses these problems, but the resources devoted to plant standardization seem insufficient to fully realize its potential to speed construction and cut costs. Issue Paper 1 discusses these problems and a possible standardization program.

While the reliability of large LWR's has been equivalent to comparable-sized fossil plants, it has been less than expected, An increase in nuclear plant availability would have a substantial effect on oil consumption, since utilities often must replace the missing base load capacity with oil-burning units. Each large LWR generates heat at a rate equivalent to more than 40,000 barrels of oil per day. The ERDA program addresses the major causes of unreliability; Issue Paper 2 discusses reliability and advanced safety and efficiency concepts.

The floating nuclear plant (FNP), which would be factory built on a barge and floated into its permanent location, offers the possibility of speeding construction and cutting costs. Utilities have been reluctant to order these plants, however, because of the general slowdown in new plant orders and because of doubts as to the licensable nature and ultimate performance of the plants. As a result, the only supplier of FNP's is now in a precarious financial condition. A proposed ERDA program to stimulate introduction of FNP's is discussed in Issue Paper 3.

High-Temperature Gas Reactor. The only American competitor to the present LWR which is near commercialization is the helium cooled high-temperature gas reactor (HTGR). It offers a higher efficiency than the LWR, equivalent to the best fossil units; a possibly more easily managed safeguards problem; potential use as an industrial process heat source because of its higher operating temperature; and freedom from midterm fuel resource worries. It is, however, more expensive than the LWR, and utilities have less confidence in its reliability because of very limited and less than reassuring operating experience with the Fort St. Vrain demonstration plant, As a result of these factors, about half of the HTGR orders have been canceled, and the manufacturer may have difficulty surviving. The HTGR concept seems to be worth developing as a viable option, but the present ERDA program may be insufficient to accomplish this, ERDA may soon have to decide whether to provide greater support or let the concept die, Issue Paper 4 discusses the HTGR potential and program.

Other Converter Reactors. At present, there seems to be little advantage to foreign converter reactors. This situation could change in the next few years if the Canadian deuterium-moderated reactor (CANDU) continues to show superior capacity factors. This reactor uses natural uranium, thus avoiding the expensive enrichment process, and consumes slightly less fuel than the LWR over its lifetime. Its lower thermal efficiency and its need for large quantities of heavy water, which require large amounts of energy to produce, tend to offset these advantages. In addition, the licensability of the CANDU reactor under existing Nuclear Regulatory Commission (NRC) regulations appears doubtful. Importation of the reactors appears undesirable for reasons of energy independence and balance of payment considerations. Alternatively, if these reactors were to be produced domestically under Canadian license, U.S. industry would have to make a costly conversion to the manufacture and support of a very different technology which probably will be superseded in the near future, The advanced CANDU is under development and shows promise of greatly extending resources and producing power more cheaply than the present design. ERDA should follow this development closely.

2. Breeder Reactors

Liquid Metal Fast Breeder Reactor. The liquid metal fast breeder (LMFBR) is the most technologically advanced of the breeder technologies both here and abroad. It is much closer to technological and economic success than the other "inexhaustible" long-term energy sources and has the potential to produce vast quantities of power early in the next century at a competitive price. It could do this in a manner that is more acceptable environmentally than any present technology. Nevertheless, it is the most controversial item in the ERDA program.

Controversy centers around the cost of the R&D program, especially relative to the funding of alternative energy sources; the economics of the LMFBR when fully developed; the quality of the design; the increased safeguards problem that will result from the large quantities susceptibility to sabotage. Issue Paper 5 discusses these issues and the program goals and problems.

The ERDA expectation of 80 commercial LMFBR units by the year 2000 is optimistic in view of the recent delay in the Clinch River demonstration plant, This is probably not critical, however, because many of these projected units could be replaced by converter reactors.

Gas-Cooled Fast Reactor. The gas-cooled fast reactor (GCFR) is a possible successor or supplement to the LMFBR, It has a higher breeding ratio and thermal efficiency and may entail more easily managed problems of safety and safeguards than the LMFBR. Technological development of the GCFR is less well advanced, however, and substantial development work is needed in such areas as component development and fuel-cycle analysis. Issue Paper 4 discusses the GCFR with the HTGR, since the two are intimately related technologically.

Light-Water Breeder Reactor. The light-water breeder reactor (LWBR) is designed to utilize much of the present pressurized water reactor (PWR) technology, Ideally, the reactor itself would fit into a present-generation PWR vessel, with some derating of thermal output, and produce as much fuel as it burns. Thus, temporary freedom from fuel resource limitations might be achieved with a small expenditure for research and development and a relatively low capital cost increment. Too few details have been released for a realistic assessment to be made. Little is now known of the fuel-cycle cost or licensing problems, and utilities have shown little interest in the LWBR concept. Issue Paper 6 covers the project and its potential.

Molten Salt Breeder Reactor. The molten salt breeder reactor (MSBR) is a totally different breeder design that has been funded for many years at a very low level, If successful, it would simplify the safety and safeguards problems because of its continuous fuel reprocessing and use of thorium fuel. The fuel breeding ratio is much better than that of the LWBR, but is unimpressive compared to the LMFBR and GCFR. The lower fuel inventory should mean that lifetime uranium requirements are no greater than for the LMFBR. Despite the many unique technical problems that remain to be solved, the MSBR offers sufficiently significant advantages to be funded at a higher level to allow a realistic determination of its potential. Issue Paper 7 discusses the relative merits and problems of the MSBR.

3. Supporting Technology

Environment and Health (Issue Papers 8 and 9). The nuclear environmental hazards during normal operations are well understood relative to the hazards associated with coal-fired powerplants and, on balance, appear relatively small. Much work, however, is still needed, especially on the question of plutonium toxicity.

Waste Disposal (Issue Paper 10). Several waste disposal options that appear technologically feasible are under consideration. Disposal in carefully selected salt beds or areas in the ocean floor are both possible. Public acceptance is a less tractable problem. A strong effort is required to allay public fears, but it must result in a technically well supported choice that will not have to be revoked, as was the plan to use the Lyons, Kansas, salt bed. Reprocessing of spent fuel with actinide removal can greatly ease the waste disposal problem by reducing the time from 200,000 years to about 500 years that wastes present a danger (and must be isolated). The relatively small volume of actinides could be stored separately in a very safe location or put back into a reactor to be burned up. With suitable dilution, the radioactivity diminishes to about the level of uranium ore in 500 years even without actinide removal. If reprocessing does not become widespread, ERDA should have ready a plan for retrievable storage of fuel elements.

Safeguards (Issue Papers 11 and 12). Nuclear material diversion by clandestine groups to construct weapons is a difficult problem which involves abnormal human behavior and potentially devastating consequences. It seems probable, however, that technical solutions can be devised to keep the risk of such diversions at acceptably low levels. The cost is not expected to be prohibitive, but a continuing effort will be required to make the system perform according to design, A promising possibility is to locate reactors and their associated fuel reprocessing plants and fuel fabrication plants together in a nuclear park. This would eliminate the transportation links and thus reduce the possibility of diversion. Siting, environmental, and other problems, however, may be greater than for present methods.

Resource Base (Issue Paper 13). All estimates of the Nat ion's ultimate uranium resources are still highly uncertain. Critics have claimed that the ERDA estimate is either too high and therefore exaggerates the potential importance of nuclear power, or that it is too low and overemphasizes the need for the breeder. Utilities already are worried about ensuring the supply of fuel for the lifetime of new reactors, perhaps in part because the price of uranium has risen sharply recently, Since very important decisions, such as the breeder timetable, depend on the estimates of U.S. uranium resources, it is vital that they be substantially more accurate, ERDA should consider expediting its National Uranium Resource Evaluation Program.

Enrichment (Issue Paper 14). The present and planned capacity of ERDA gaseous diffusion enrichment facilities is fully subscribed, and new capacity will be required by about 1985. The Government anticipates that private industry will provide the needed expansion, but it is estimated that industry would require 9 or 10 years to learn the technology and get their first plant operating. If industry and Congress do not take positive action very soon, ERDA itself must consider building another enrichment plant or increasing the capacity of existing plants. The centrifuge separation technique shows great promise, but it is not as far advanced as gaseous diffusion; nevertheless, the succeeding generation of commercial enrichment plants may well be a centrifuge type. Centrifuge technology and, to an even greater extent, the laser separation technique, have potential for illicit use because of their adaptability to small-scale production.

Fuel Recycle (Issue Paper 15). The NRC has tentatively delayed plutonium recycle until the safeguards issue is adequately addressed. Plutonium recycle greatly increases the risk of diversion of weapons-grade material or accidental release of a highly toxic substance, In addition, the economics are now only marginally attractive. Industry, however, expects to proceed when possible as reprocessing should somewhat improve the economics of the fuel cycle, facilitate waste storage, and extend the uranium resources. Experts are divided on this issue. Some experts want to aid industry as ERDA proposes to do; others feel the hidden social costs will be greater than any possible societal benefit. While the lack of recycle capability will not become critical until the breeder is commercialized, the issue should be resolved soon because LMBFR economy rests on plutonium recycle, and a significant energy source is being neglected.

Public Acceptance (Issue Paper 16). There is a great deal of opposition to the siting of almost any nuclear plant. While some objections are irrational, real concerns such as the emergency core cooling system performance, safeguards, and waste disposal have not yet been fully resolved, ERDA should discuss these problems publicly and candidly while dispelling public misconceptions, such as the possibility of nuclear explosions in powerplants.

4. Fusion (Issue Papers 17 and 18)

There is a consensus that if nuclear fusion can be successfully harnessed to give economic power, it would be a very attractive means of supplying much of the Nation's electrical energy needs by the next century, The abundance of cheap fuel, the low level of radioactive waste products, and nuclear explosive materials are among the advantages that would accrue from successful fusion power, The required research and development deserves favorable funding within the Nation's long-term energy program. However, the scientific demonstration of fusion feasibility—that is, that the required temperatures and containment for thermonuclear burn can be achieved—has yet to be shown.

Substantial advances have been made in recent devices (tokamaks and laser experiments), but there is no certainty that these experiments can be scaled up in size and power to give the required conditions, The R&D will necessarily take many years, will be very expensive, and as yet carries no guarantee of success. Nevertheless, the potential is so great that it should be vigorously pursued.

There is concern, however, as to whether ERDA has narrowed the focus of its fusion program too much by its heavy concentration on the tokamak concept. The ERDA Plan calls for scaling up the tokamak device to machines in which scientific feasibility (energy "breakeven") can be achieved. Although this scaling up appears to be a necessary process to achieve success in the fusion program, the cost and complexity of these next generation machines raises questions as to whether options on other promising fusion concepts can be kept open in case the tokamak concept is not successful. If continued assessment of program directions is not carefully maintained, there is danger of premature abandonment of other fusion concepts.

The economic harnessing of fusion power will require several new technologies, including new materials for the reactor walls, economic storage of large amounts of energy, large superconducting magnets, and the safe handling of tritium, Since developing these new technologies will take many years, adequate R&D programs should be started now to avoid possible delays in the overall program, There is evidence that the ERDA Plan has done this. Continued assessment is a necessity to ensure a balanced effort.