EIR Science & Technology

DOE advisers set plan for a U.S. nuclear renaissance

Marjorie Mazel Hecht reports on a little-publicized plan issued by a Department of Energy advisory committee, to rescue nuclear power in America from the environmentalist dust.

A little-publicized report issued in October 1986 by the Energy Research Advisory Board (ERAB) to the U.S. Department of Energy (DOE) makes it clear that the U.S. nuclear industry must not stay buried in the environmentalist dust. Instead, the four-volume ERAB study lays out some very minimal steps for the United States to launch a nuclear renaissance and develop the advanced nuclear technologies to take the nation into the 21st century.

Although its recommendations are quite modest, the ERAB report is unequivocal in pointing out the absolute danger to the nation's security—"military, environmental, or economic"—if the present downward course of nuclear-power development is not reversed. Unfortunately, the report assumes a limited budget perspective and a limited estimate of increase in electricity demand (2-3% annually). Nevertheless, it provides the necessary information about the U.S. nuclear capability from which to plan a program for more rapid industrial growth at home and in the rest of the world.

What kind of nuclear program the United States would need to reindustrialize at home and begin to industrialize the developing sector was spelled out by the Fusion Energy Foundation in the Oct. 15, 1985 *Quarterly Economic Report* of *EIR*. To meet such a goal, the United States would require about 650 gigawatts of additional power for itself by the year 2000, and another 650 gigawatts to meet the urgent needs of the developing sector. (This is considerably more than the 300-gigawatt increase called for by the DOE by the year 2000 for the United States alone.) The way to do it, the FEF study said, is by mass producing modular nuclear plants using standardized parts and assembly-line shop fabrication. With a crash program to gear up such an assembly-line production, once the required parts were "on the shelf," the process of putting a small plant on-line could be reduced to as little as two years.

In addition, as the nation sets a goal of going back to the Moon and then on to Mars in the next 40 years, we will have to break through the nuclear technology barrier to the next frontier—thermonuclear fusion for energy production as well as propulsion. Thus, the mass production of modular nuclear plants is simply a way of powering the transitional growth period to a fusion economy in the 21st century. One intermediate step on the way is the fusion-fission hybrid reactor, a fuel-breeding power reactor that is not even touched on in the ERAB report.

With this mission perspective in mind, we can welcome the assessment of the ERAB panel, especially its review of the extensive research already ongoing in advanced nuclear technologies both here and in other countries.

ERAB's assignment

The ERAB report was requested by Secretary of Energy John S. Herrington in August 1985 as a review of the Department of Energy's draft Strategic National Plan for Civilian Nuclear Reactor Development. "It is timely that we review our approach to nuclear energy research and development so that it can continue to be a prime contributor to America's energy security, stability, and strength," Herrington wrote to the ERAB chairman. "I am particularly concerned that we may not be doing enough to ensure that the nuclear energy option will be available to meet our future needs." The Department of Energy is now in the process of reviewing the ERAB report and is reportedly making some changes in its draft report as well as in the 1988 draft budget.

The ERAB panel—whose members include industry and utility experts, private consultants, and university representatives, all with expertise in the nuclear area—also expanded its task to include a review of the institutional factors holding back nuclear power development. There were ERAB subpanels on three topics: light-water reactor utilization and improvement, advanced-reactor development, and institutional challenges. The final report lays out a series of steps the DOE must take to regain U.S. leadership in the nuclear area and ensure national energy security, including regulatory legislation, budget measures, international collaboration, and an educational campaign to put out some "balanced" information on nuclear power.

The ERAB report also points out that a crucial factor in ensuring the nuclear option is how the DOE deals with solving the problem of nuclear waste, and it recommends continued work on a monitored, retrievable waste-storage facility. Such a facility would not permanently bury the waste, therefore preventing its future reprocessing for use as nuclear fuel or for separation into valuable isotopes.

One of the most useful points of the report is its sharp criticism of the DOE plan's inadequate treatment of regulatory and other institutional problems. As the ERAB report states the problem: "It is clear that public policy, as established by the U.S. Congress and dating back to 1954, supports the development and utilization of nuclear energy for electricity generation under federal regulation to 'protect the public health and safety.' In spite of this public policy, *the Federal Government technical nuclear regulatory process has become a major component of the institutional impediment to the continued deployment of nuclear energy for electricity generation in the United States*." (Emphasis added.)

The first item proposed by the ERAB report is an obvious one; it calls for exactly what one would have expected an avowedly pro-nuclear administration to do: ERAB recommends that as an "initial step," "the Secretary of Energy urge the President to issue a strong policy statement supporting the continued development and deployment of civilian nuclear power, including directives to government agencies to create a more favorable climate for such development and deployment, *without reducing protection of the public or the environment*."

Next, the ERAB report recommends that a Presidential Commission be established to develop long-range objectives for U.S. nuclear power use, to provide international leadership, and to oversee the recommendations outlined in the report. (Some specific recommendations are discussed below.)

Can the patient be saved?

From an objective standpoint, the U.S. nuclear industry, once the world leader, is now half dead. The national security issue is how fast can it be revived, and how fast can it catch up in those areas of advanced nuclear technology where the United States, via budget cuts, has taken a back seat?

The seriousness of the patient's condition is well known, and the media almost daily report on new attempts by the environmentalists to pull the plug. Since the early 1970s, there have been more than 100 nuclear power plant cancellations. During the nominally pro-nuclear Reagan administration, there have been 57 U.S. nuclear plant cancellations and no new orders; 18 plants have received construction permits, but of these, 3 are indefinitely delayed. There are an additional 8 plants awaiting approval to operate, 5 of which have a low-power license, and 3 of which have a full-power license. In the case of two of these plants, Shoreham in New York and Seabrook in New Hampshire, regulatory wrangles preventing the fully-completed plants from opening are costing millions of dollars per day.

Not only have there been no new orders for nuclear plants in the United States since 1978, but also ***no nuclear plant that was ordered since 1973 is now operating or will be completed.*** As the ERAB report bluntly states, "There is a general consensus that there will not be another nuclear plant order under current conditions."

Today there are 105 operable nuclear plants in the United States, producing 91.5 gigawatts of power, 15% of the electricity consumed. Although this is the largest number of plants in any one country, it is by no means the largest ratio of nuclear-generated power to total power. Western Europe, for example, is 30% nuclear, with France leading the world at 65%.

Furthermore, the United States has abdicated leadership in advanced nuclear technology areas and even state-of-the-art areas. For example, thanks to President Carter, the United States is the only nuclear nation that does not reprocess spent fuel from civilian nuclear plants. Therefore, instead of recycling 96% of our nuclear waste, the United States stockpiles it, providing the antinuclear environmentalists with a political hot potato. The United States also virtually abandoned its breeder program and its high temperature gas-cooled reactor program, both of which are being pursued in the other nuclear nations. In fact, ERAB estimates that the United States is now 10 to 15 years behind in breeder technology.

Perhaps the most telling measure of the sad state of the U.S. nuclear industry is how far it has slipped from the high hopes of the Atomic Energy Commission (AEC) in the optimistic years of the 1960s and 1970s. In 1971, the AEC projected that by 1985, the United States would be producing 300 gigawatts of nuclear power; in actuality, the United States produced 77.8 gigawatts that year, less than one third of the goal. Even the AEC's less optimistic projection made in 1974 for 1985, 275 gigawatts, is more than three times the actual 1985 figure achieved.

Light-water reactors

The ERAB subpanel on light-water reactors makes a strong case for government action to get the nuclear industry back on its feet:

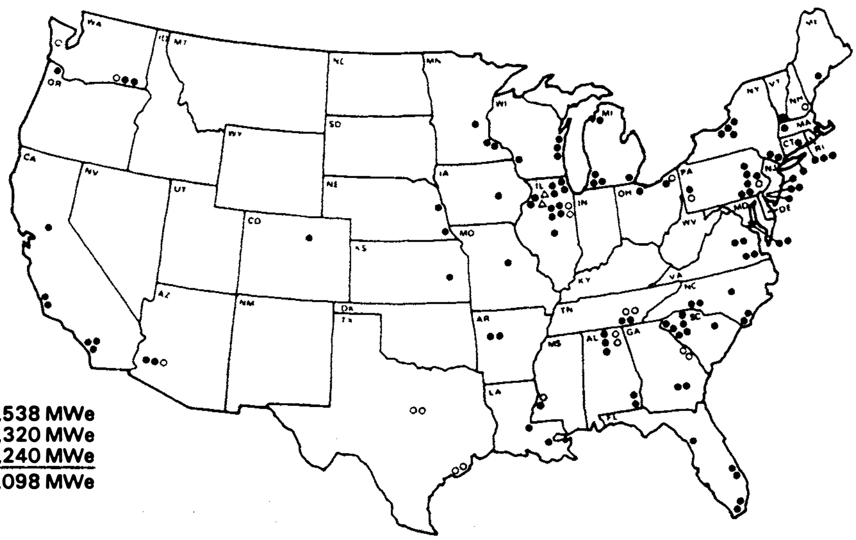
FIGURE 1
Nuclear Power Plants in the United States

If there is to be any real economic recovery, the United States would require about 650 gigawatts of additional power by the year 2000. Even taking the conservative Department of Energy forecast of a 3% annual growth rate in electricity use, the nation would need 300 more gigawatts.

Key
- ● Reactors With Operating License
- ○ Reactors With Construction Permit
- △ Reactors On Order

105	Reactors operable	91,538 MWe
20	Reactors with construction permits	23,320 MWe
2	Reactors on order	2,240 MWe
127	Total	117,098 MWe

Source: Atomic Industrial Forum, January 1987



The subpanel believes that an adequate, affordable, reliable electric supply is an essential and necessary input to economic growth in our industrialized society. For the purpose of national security a diversity of energy sources is required including an expanded deployment of light-water reactors to meet this country's growing demand for electricity. *However, because of the important government responsibilities, nuclear power can be a future economic alternative only if it receives strong support from the Federal Government and DOE.*

The national security, economic, and environmental risks of a future U.S. society with only coal as a long-term domestic energy resource for baseload electricity generation, are far too great to allow nuclear energy to disappear as a domestic energy resource.

Stating that "an adequate, economic, and secure supply of electricity is one of the prerequisites for continued economic growth," the subpanel notes that according to the latest estimates of growth in demand for electricity of between 2 and 3% per year, new baseload capacity will be needed in the early 1990s.

"There are some who feel that rotating brown-outs or black-outs are a possibility in the 1990s," the subpanel states. "A more probable scenario, however, is that our electric utilities will, in fact, use more oil and gas and import more electricity from Canada, making our electricity and the goods and services which rely on electricity, more expensive. If this happens, it will have the effect of gradually lowering our standard of living and our competitiveness in the world market. It is the *gradual* deterioration which is insidious since it may not prompt action to correct it."

The subpanel then makes a series of broad recommendations to the DOE, giving top priority to activities directed to ensure the continued successful operation of currently operating light-water reactors, second to activities directed to the successful completion of plants currently under construction, and finally to activities to set the stage for future plants. The report recommends that the DOE study whether it would make sense to revive the light-water reactor projects that were canceled in construction—reactors that represent a $10 billion investment.

Specifically, the subpanel calls for a strong presidential policy statement at a public forum that announces the formation of a presidential commission on electricity and nuclear power. In addition, the subpanel recommends the setting up of a task force to work with the DOE on institutional, regulatory, and financial issues. Among the suggested programs to be developed by this Task Force is reform of the nuclear licensing process, including reforms that encourage standardization, one-step licensing, and limits on retrofitting—all of which are now problems that delay and increase the costs of nuclear construction. One of the stated goals of the regulatory reform is to give industry some incentives for achieving certification from the Nuclear Regulatory Commission for several standard light-water reactor designs by the year 1988.

Regulatory chaos

The subpanel bluntly states that the licensing regulatory process established by the Atomic Energy Act of 1954 has "not kept pace in an orderly fashion with the development of nuclear electric power technology" and "no longer serves the best interest of the public, the regulator, or the private industry."

To put this more concretely, since the Three Mile Island accident in 1979, the antinuclear activists have intervened in the regulatory process to the point that this has stretched the construction time from four to 14 years, and made the cost of construction prohibitive and raised the cost of electricity not just for the activists, but for all nuclear electricity consumers.

The subpanel notes that the "current system postpones resolution of a number of issues until late in the licensing process when the plant is essentially complete and billions of dollars have been invested, the interest on the borrowed money approaches $1 million per day, and there is uncertainty over when the issues will be resolved and at what ultimate cost."

Further, the subpanel says, "There is an undisciplined process for imposing backfits that, in addition to adding unnecessary costs to the plants, in some cases may have degraded, not improved, public health and safety." In addition, the subpanel criticizes the "use of adjudicatory procedures to resolve technical issues and diversion of legal and technical resources to issues which have little real public health and safety impact." Further, the subpanel notes the "lack of an orderly means for public participation in the licensing process."

What the subpanel recommends is joint government-industry support to move legislation through Congress that would include standard plant certification, early site approval, and a combined, single operating license procedure that would mean both an early resolution of issues and an opportunity for the public to review a more complete design early in the process. In addition, the subpanel recommends a centralized process to review any proposed backfits that would consider both cost and safety.

Advanced nuclear reactors

The modesty of the ERAB recommendations for a U.S. nuclear renaissance is most noticeable in the third volume of the report, authored by the subpanel on advanced reactor development. This volume discusses three main areas: improved light-water reactor systems, the liquid metal-cooled breeder system, and the high temperature gas-cooled reactor, and it reviews recent advances in both the national laboratory programs and in industry research.

The ERAB subpanel states its task as one of reviewing the DOE plans for advanced reactor R&D "under current realities"—federal budget limitations and the "apparent excess of electrical generation capabilities" in the United States. Nevertheless, it is in this subpanel's report that one gets a sense of the tremendous potential of advanced nuclear technologies to produce electrical power more efficiently and cheaply, while providing new energy applications for indus-

Information à la Carter

During the Carter administration, the public education materials that had been produced in the spirit of the Atoms for Peace era were literally buried and replaced with new items that catered to the prejudices of the anti-nuclear environmentalists—anti-growth, anti-industry, anti-science. Although the Reagan administration attempted to put out more balanced materials, Congress squelched the plan.

The ERAB report recounts this process as follows:

"During the Carter administration, a large amount of money (over $100 million) was spent by the federal government on public information programs on conservation, solar, and other renewable energy resources, while the nuclear and coal public information programs were essentially nonexistent. In December of 1980, there was a Congressional report prepared by the staff of the Subcommittee on Energy Research and Production of the Committee on Science and Technology. The basic findings of this report were the following:

1) The Department of Energy's programs for public information and education do not reflect an objective, balanced, or realistic view toward energy resources and the problems and opportunities in meeting the nation's requirements for energy.

2) The Department's information and educational programs largely ignore coal and nuclear energy or depict them in an unfavorable light.

"The basic recommendation of this report was as follows:

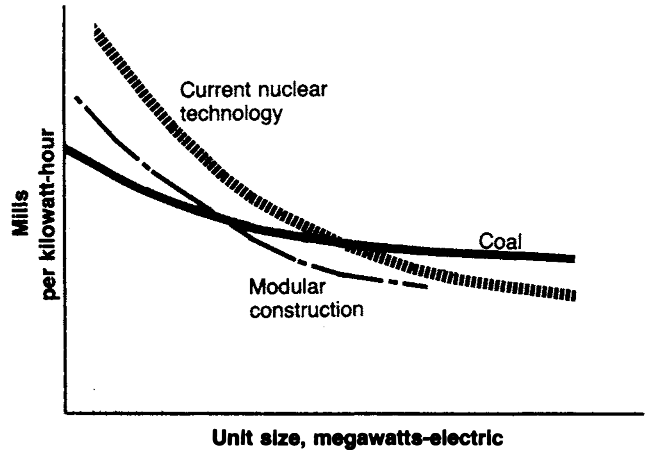
"The Department of Energy should establish, at the highest level, an effective policy and the appropriate procedures, for assuring a balanced program of public information and education on all energy forms, consistent with their place in the nation's overall energy mix.

"In response to this Congressional report, the Department of Energy in 1981 began a planning process to put into place a new nuclear power public information program. While it was still in the planning stage, Congress became aware of it, held hearings, and put pressure on the Department not to move forward with it. As a result, this program did not become a reality."

trial use. The ERAB R&D price tag for such benefits is a paltry $200 million per year for the next decade, but as the subpanel report warns at the outset, even this meager sum is endangered:

> The current DOE advanced reactor program is in danger of being totally eviscerated by the cutbacks being proposed in government funding of this important work. For the first time in the four-decade-long history of the federal government's commitment to research and development on the peaceful uses of nuclear energy, the administration appears to be pulling out. Funding has decreased by almost fourfold since 1983 and even larger cuts are proposed for fiscal year 1987. Virtual elimination of the federal role in civilian nuclear power R&D will send a loud signal to private industry, as well as to the international community, that the U.S. is relinquishing its leadership role to overseas interests in this vital element of national energy policy.
>
> In our opinion, pursuit of this course of action would be a serious and irrevocable mistake. Meaningful research simply cannot be conducted in an environment of on-again, off-again funding. This nation's investment in nuclear power is too great and its past and future contributions too significant to allow liquidation of four decades of advanced reactor R&D by default. Billions of dollars of consumer savings in addition to billions of dollars of export sales and thousands of high technology jobs for U.S. workers are at stake. . . .
>
> The importance of filling this need for advanced nuclear systems is underscored by the key role that electricity plays in ensuring a strong U.S. economy and by the growing contribution of nuclear power to the nation's electricity production. Since the 1973 Arab oil embargo, electrical consumption has risen by one-third in the United States, despite a 13% decline in the use of all other forms of energy. During that period, the residential sector increased its use of electricty by 34%, the commercial sector by 48%, and the industrial sector by 22%.
>
> The nation recorded an all-time production record of 380 billion nuclear power-generated kilowatt-hours in 1985. That is more electricity than is generated from any U.S. source except coal. . . .
>
> The current excess of electric power in the U.S., along with the present oil and natural gas "glut," makes it difficult to keep in perspective the longer-range need to ensure economic and plentiful fuel supply. Nuclear power promises to be a virtually unlimited source of energy for the U.S. and for the world for hundreds to thousands of years. The important point that seems to be forgotten, disregarded, or dismissed at the present is that development progress over the past four decades shows that no scientific or engineering unknowns are standing in the way. What is needed is to ensure that advanced nuclear systems can be deployed economically with an acceptable environmental impact and with proliferation control. What is also needed is the national resolve to complete the R&D job that was initiated four decades ago.

FIGURE 2
Economy-of-scale versus power technology



The loss of economy-of-scale with smaller, modular reactors is compensated for by the cost savings of assembly-line production and the sharing of facilities like turbines and control centers, as well as savings from not having to license each plant individually after the basic design is licensed.

Source: Energy Research Advisory Board Civilian Nuclear Power Panel, Subpanel II Report, Advanced Reactor Development, Vol. III, Oct. 1986, p. II.1-5.

The international market

The ERAB subpanel sees the advanced reactor research as critical for helping U.S. nuclear vendors maintain a presence in the international market, where the report points out there will be a need for 27 to 30 nuclear units in the next three to four years. U.S. vendors have not had a foreign nuclear plant sale since 1978, the report notes, and the interest rates of the Export-Import Bank for foreign buyers are not competitive with the government-supported financing that other nuclear nations can offer developing sector countries.

In addition, the report notes, the Carter administration nonproliferation policies, still in effect, have created "uncertainties" for countries that rely on the United States as a nuclear supplier. The ERAB subpanel sees as a "reasonable" expectation that U.S. vendors could sell at least 10 of the 27 or so nuclear reactors likely to be ordered abroad. "Such sales could result in payments up to $10 billion and in 200,000 man-years of direct employment for U.S. workers," the report notes. Further, "sales of small safeguardable reactors to less developed nations could further reduce the balance-of-trade deficit and increase U.S. employment."

The breeder reactor

"In 1945, Enrico Fermi stated that 'the country that first develops a breeder reactor will have a competitive advantage in atomic energy,'" the ERAB subpanel notes. "Six years later in 1951, the U.S. was the first country to demonstrate the technical feasibility of breeding at Arco, Idaho, in the experimental breeder reactor EBR-I. This reactor not only demonstrated breeding but was the first reactor in the world to produce electric power from fission."

Despite continued progress, however, the U.S. breeder program came to a halt in 1984 when the Reagan administration cut its budget and relegated breeder development to "private enterprise." Now, France, West Germany, Britain, Japan, India, and the Soviet Union are moving ahead with breeder technology, leaving the United States 10 to 15 years behind. As the ERAB report spells out the details:

> The breeder budget has been cut back approximately $100 million each year for the past four years, from approximately $600 million to $200 million in fiscal year 1986, with a recommended cut by OMB to $129 million in fiscal year 1987. If the current program is not maintained, the U.S. will not only fall further behind the rest of the world, but will not be able to capitalize on its investment to date and will have so decimated the infrastructure that it will take years to reestablish the capability that will have been lost.

The ERAB subpanel, however, makes the best of these setbacks, reasoning that breeders will not really be economically essential until well into the 21st century, when uranium reaches the price of $100 per pound, thus driving up the cost of fueling light-water reactors. For this reason, the subpanel recommends that government R&D focus on improving the economics of the breeder by developing innovative reactor designs, a metal-alloy-fueled reactor with pyrometallurgical reprocessing, and an ultra-long-life oxide-fueled reactor core. In this way, the subpanel says, the end-product will be a "design concept that could far exceed any current projections of breeder plant economics either in the U.S. or in foreign breeder programs."

Research advances

While this go-slow approach of the subpanel is disappointing in its acceptance of budget constraints as a necessity, all of the advances and ongoing research discussed in the report could of course be speeded up and come on-line not only faster but in greater numbers. Most exciting of the advances reported on are the conceptual designs by General Electric and Atomics International (part of Rockwell International) for a small, modular breeder reactor in the 100 to 300 megawatt-electric (MWe) range. These would be standardized nuclear designs that could be mass-produced in a factory and transported by barge or rail to a site where the rest of the plant would be conventionally constructed. Chief among the advantages—such as shorter lead times, ability to group several reactors together depending on need, and reduced financial risk—is the reduced cost, which promises to overcome the traditional economies of scale associated with nuclear power plants (see **Figure 2**).

The DOE facilities involved in testing innovations for the breeder program, such as passive safety features and fuel configurations, are the Fast Flux Test Facility (FFTF) in Hanford, Washington, and the Experimental Breeder Reactor II in Idaho. The FFTF is working on an advanced fuel design with an operating lifetime three to four times longer than earlier fuel systems, a capability the subpanel says is unmatched in the rest of the world and one that will help make the new breeders competitive with today's light-water reactors. Such an extended-life fuel system, which can stay in the reactor core three to five years, uses new materials that are resistant to radiation damage.

The savings from such a long-life core are considerable. Westinghouse estimated that the fuel cost would decrease from about 13.5 mills per kilowatt/hour (kWh) to less than 7 mills.

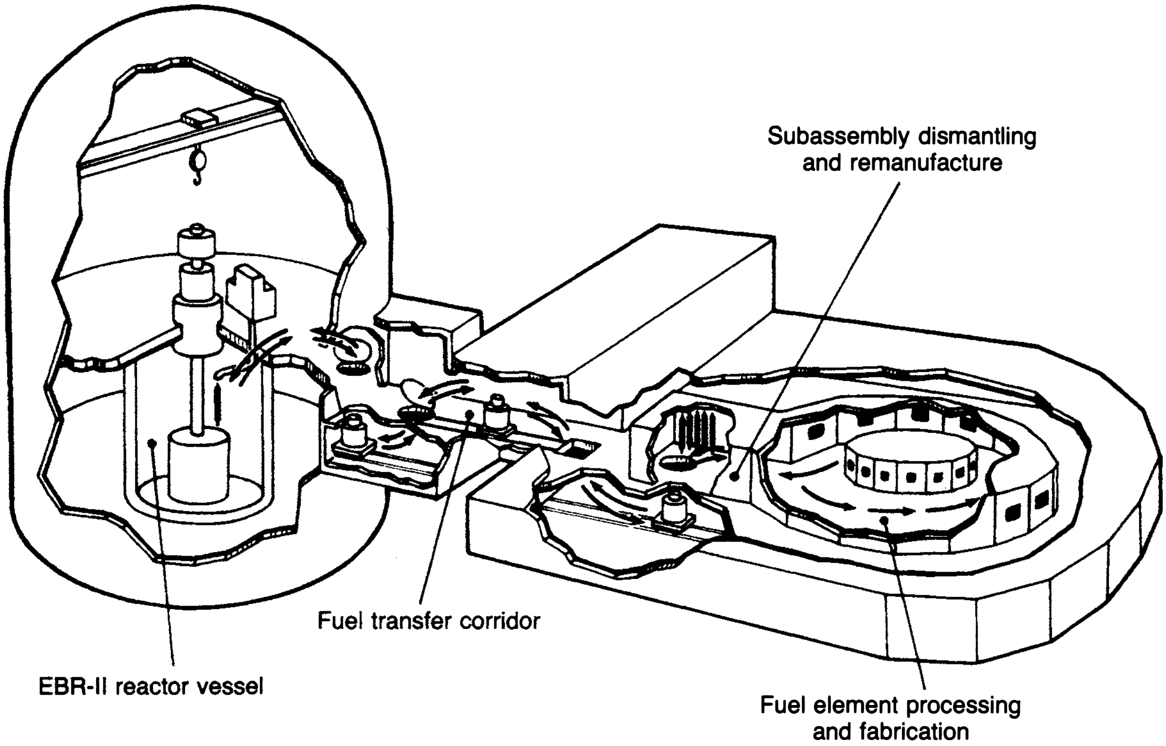
The FFTF is also testing new safety features, including passive systems that ensure reactor shutdown and core cooling if a problem arises. These systems give the plant operators additional time to correct a problem.

Also at Hanford is a Westinghouse plant, Secure Auto-

The Chernobyl bogey: for export only

Chernobyl has become the new environmentalist bogeyman, the very mention of which is used to imply that nuclear power is not safe, that existing plants should shut down, and that new plants should not open. Yet while the Soviet-supported Greenies in Europe and the United States were escalating their fight against the nuclear industry, moving to riots and sabotage in Europe, the Soviets were busy putting two of the four damaged Chernobyl reactors back on-line, one at 50% power and the other at 90%. And as U.S. political figures like New York Governor Mario Cuomo and Massachusetts legislators Sen. Ted Kennedy and Rep. Edward Markey have waved the bloody Chernobyl banner in their fight to keep closed the already completed Shoreham plant on Long Island, N.Y. and Seabrook plant in New Hampshire, the Soviets announced that they plan for a fivefold increase in nuclear capacity by the year 2000.

FIGURE 3
Experimental Breeder Reactor II and Fuel Cycle Facility



In this Argonne National Laboratory experiment, used fuel from the EBR-II breeder reactor was reprocessed in a remotely controlled facility attached to the reactor that removed the fuel from the core, reprocessed it, and returned it. This is the model for a new Integral Fast Reactor design that Argonne says "virtually elminates any chance to steal or divert nuclear fuel." After the first fuel is loaded into the core, nuclear fuel and waste products would never enter or leave the plant site during its working lifetime.

Source: Argonne National Laboratory

mated Fabrication or SAF, which is scheduled to begin production in 1987 to test fuel fabrication for liquid metal breeders. The SAF plant will use automated, remotely controlled processes for fuel fabrication that make use of new systems for safeguarding the nuclear material and also reduce the radiation exposure for the operating staff by a factor of 15. The plant uses an advanced robot developed for handling hazardous materials as well as new fiber-optic and laser technologies to inspect the product.

The EBR-II, operated by Argonne National Laboratory, is experimenting with new metal alloy fuels—plutonium, uranium, and zirconium—as well as a reprocessing system that processes spent fuel into new fuel at a site adjacent to the power reactor (see **Figure 3**). Argonne expects that its pyrometallurgical process will be a breakthrough in fuel-cycle costs and that it will be attractive in terms of nonproliferation because plutonium is never separated into a single element. ERAB notes that Argonne has estimated that a central reprocessing/fuel fabrication facility serving several modular breeder reactors totaling 1,400 MWe, would fit in a 32-foot-by-52-foot building and cost $48 million.

Two other modular reactor designs noted by the subpanel are General Electric's PRISM, the power reactor inherently safe module, and Rockwell International's SAFR, or sodium advanced fast reactor. PRISM is a 135-MWe liquid metal breeder reactor designed to be grouped in threes, with one turbine serving all three modules. GE estimates that the capital cost of a PRISM plant can be within 30% of a similar-size coal plant and can be constructed in less than four years. Each plant breeds enough fuel to refuel itself.

SAFR is a 350-MWe design that stresses simplicity and low construction costs, with a reactor vessel 39 feet in diameter. This size, which Rockwell expects to group in sites with four modules, was found to be the optimum both for factory fabrication and new features such as passive decay heat removal.

The high-temperature gas-cooled reactor

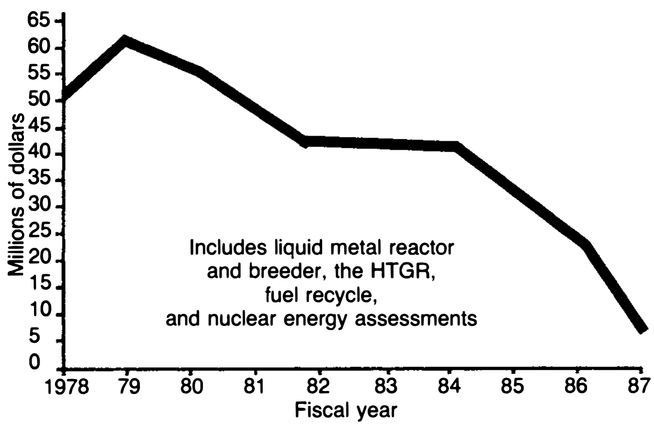
Another front-runner candidate for mass production as the next-generation nuclear reactor is the HTGR, or high-temperature gas-cooled reactor. As the ERAB subpanel put it, the modular HTGR "appears optimum for near-term deployment." The HTGR is not a new concept; it has been under development for 35 years, and the United States has spent $1.5 billion on it, two-thirds of that coming from the private sector.

The HTGR has a graphite core, a ceramic pebble fuel, and a helium gas coolant, all of which make it highly efficient as an electricity producer and as a process heat producer. (More than 70% of the energy used in U.S. industry is nonelectric, in the form of heat or steam.) The HTGR can produce much higher temperatures than light water reactors because the graphite has a very high vaporizing point (about 3,650° C.); there is no boiling point to worry about in the coolant because it is a gas, not a liquid; and the ceramic fuel pellets do not have the inherent temperature limit of a metal-clad fuel. The fuel pellets, whose design came out of the space program research, consist of a particle of fissile uranium or nonfissionable but fertile thorium, about the size of a grain of sand and enclosed in a graphite and silicon carbide shell.

The 330-MWe demonstration HTGR at Ft. St. Vrain in Colorado, has achieved steam temperatures of 1,000° F. (compared to 350° in a light water reactor), and a net efficiency of 38.5%, which ERAB notes is the highest of any nuclear plant in the United States. (The average heat-to-electricity conversion efficiency is 32% in a light water reactor.) Another advantage is that there is no possibility of corrosion in the piping or metal parts, because the coolant is a chemically inert gas.

FIGURE 4

Nuclear Technology budget at Oak Ridge National Laboratory



The dramatic decline in the nuclear research budget at this national laboratory is typical of the course of nuclear R&D funding. Oak Ridge originated much of the gas cooled reactor development in the United States and is now the lead laboratory for the HTGR program. The ERAB report sets a minimal level of $200 million annually for advanced reactor development.

Source: ORNL

At the same time, these HTGR characteristics provide inherent safety features. Helium, for example, unlike water, is virtually radioactively inert. The gas has a low neutron absorption cross section, which means that even if the coolant were bombarded by neutrons from fissioning fuel (an extremely unlikely event), it would not become radioactive. In the 140-MWe modular HTGR design recommended for further development by the ERAB subpanel, the design limits the core power size and power density so that the decay heat generated inside the core can be removed passively—that is, without operator intervention—using conduction, radiation, and natural convection without releasing any significant amount of fission products from the core. The idea here is to design the core so that the core temperatures don't exceed 1,600° C., below which the fuel particle coatings lock in all fission products.

The ERAB advanced reactor development panel concludes by calling for the development of ultra-long-lived reactor cores, the use of metal alloy fuel along with the integral reactor concept under development by Argonne, both the modular breeder and the modular HTGR (with a winnowing process to select the best design in each area), a more aggressive international research effort, and concentration of DOE funding for those national laboratories "having the relevant test bed facilities." Again, accepting the budget limitations as "evident," the subpanel also calls for innovative funding arrangements such as selling the power from some of the experimental laboratory reactors in order to support the ongoing experiments! In addition, the subpanel opposes the use of money "previously slated for civilian advanced reactor development to assist the military program," recommending that such funds be provided by the SDI budget.

Finally, the subpanel recommends that some of the DOE advanced reactor budget be allocated to universities, "contingent on matching funds from nonfederal entities for nuclear based research to ensure a flow of highly qualified talent for the nuclear industry." The subpanel makes the point in the following quote from a paper prepared by the Nuclear Engineering Department Heads Organization of major U.S. universities, that if this is not done, there won't be any qualified personnel around to staff a nuclear renaissance:

> The current decline of nuclear energy education in the United States threatens the ability of the country to supply nuclear energy professionals. Without such professionals, the nuclear industry will eventually find it impractical to maintain the option of using nuclear energy for power generation. . . . Some educational experts speculate that in five years, if the current trend continues, nuclear energy education programs will have difficulty gearing up to provide the necessary nuclear energy professionals for a resurgence of nuclear power. . . .