Floating Nuclear Plants: Power from the Assembly Line

The still somewhat obscure concept of producing floating nuclear plants (FNP's) by assembly line methods and putting them offshore received a boost on 11 February at the international energy conference held in Washington. Addressing the delegates, William E. Simon, administrator of the Federal Energy Office, referred to nuclear power and the breeder reactor as an essentially inexhaustible energy source and, for the long run, as the most important answer to the energy problem. Simon then spoke of the FNP concept as of major significance even for the near term.

"We are rapidly reaching the stage where we could be mass producing floating nuclear power plants," he said. "Such power plants can be produced in quantity and floated to locations through the world to produce power rapidly. This is not a long-range concept, but something which could be initiated immediately. The technology, ideas, and production facilities of many nations can be combined in developing these plants."

Although the FNP concept is more speculative and less proved than Simon's remarks suggest, there is probably a better than even chance that the first FNP's will be produced by 1980. Since 1971, Offshore Power Systems (OPS), a joint venture of Westinghouse and Tenneco, has been preparing to build a FNP manufacturing facility on the St. Johns River at Jacksonville, Florida. Westinghouse has, along with General Electric, been one of the two leading manufacturers of both naval propulsion and commercial power reactors. A Tenneco subsidiary, the Newport News Shipbuilding and Drydock Company, has had much experience in the construction of nuclear ships, having built the *Enterprise* and three other aircraft carriers as well as numerous lesser vessels.

Besides whatever advantages are peculiar to it, the FNP concept reflects a trend in the nuclear industry to emphasize standardization in the design and manufacture of power plants. The absence of standardization has contributed importantly to the equipment failures, licensing delays, and other problems that have troubled utilities and manufacturers since the construction of nuclear power plants began in a big way in the mid-1960's. The fact that the FNP's could be among the first standardized plants—and be the only ones fully standardized (because the FNP would require no special adaptation to a given site)—is one of its major selling points.

Nevertheless, despite the current momentum of the OPS project, this endeavor has given rise to some substantial questions of public policy. The Florida Audubon Society has sought, thus far unsuccessfully, to stop the project pending a decision by the Atomic Energy Commission on whether the OPS facility will be licensed to manufacture the first eight FNP's. Without itself rejecting the FNP concept as unsound, the society has argued that certain publicly owned wetlands, which would be filled for the manufacturing site, should not be preempted until the OPS project has been officially reviewed as to all of its implications. (The Audubon suit raises still other issues, but they are not germane here.)

Specter of a Nuclear Accident

The society has noted that Henry W. Kendall, MIT physicist and a leader of the Union of Concerned Scientists, has suggested that the consequences of a major accident involving a sea-based reactor could be even worse than the consequences of a reactor accident on land. Testifying last March before a congressional committee, Kendall said:

> . . . when the remains of the reactor core and waste products melt their way through the reactor containment structures . . . contact between this material and the ocean water will cause the certain release of a very large quantity of solid radioactive wastes into the world's oceans. Such an event is a catastrophe of a kind the country has never experienced. There is in a large nuclear plant, for example, enough strontium-90 to contaminate *thousands of cubic miles* of water above permitted AEC tolerance levels. . . .

In a petition unrelated to the Audubon suit, the Natural Resources Defense Council (NRDC), a public interest law group, has called on the AEC to prepare a "programmatic" environmental impact statement on the FNP concept, proceeding from the assumption that large numbers of FNP's might ultimately be moored offshore. The NRDC is concerned in part about the pressures that could be put on the coastal zone by a variety of possible new activities, from the construction of FNP's and deepwater ports to the extraction of minerals and oil and gas.

The $210-million OPS facility, which may soon be under construction, is to consist of these major elements:

1) production shops to manufacture and assemble components and subassemblies;

2) a 450-foot-wide graving dock (drydock) in which huge barges, or floating "platforms," will be assembled;

3) a wet slip into which the barges will be launched—the slip will have eight stations, and, as a new barge enters the slip, the others which preceded it will each advance one station, assembly-line fashion;

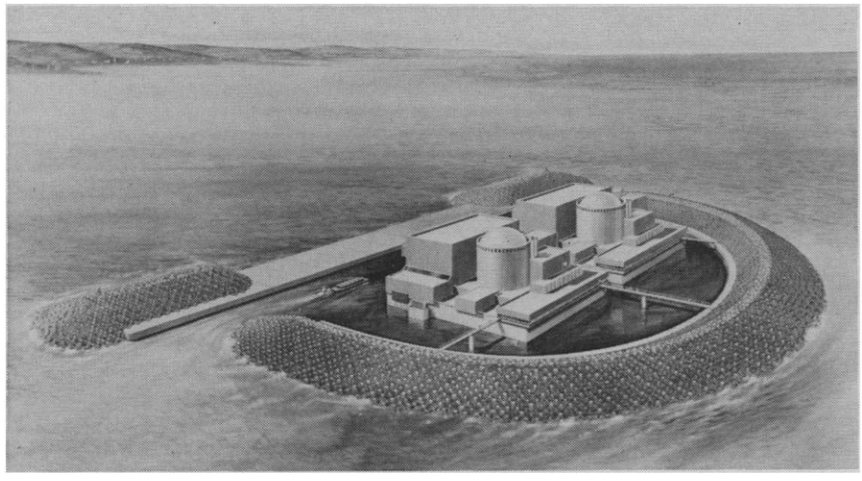
4) a huge gantry crane (with a span of 675 feet, a height of more than 300 feet, and a lifting capacity of 900 tons) that will be used to put the larger plant components in place;

5) a facility beyond the wet slip for testing the FNP's (without nuclear fuel) as they emerge from the wet slip.

The FNP's, if built, will be one of the strangest looking things ever seen at sea. The total structure, barge and power plant together, would be about 400 feet square, have a 32-foot draft (in salt water), rise 177 feet above the waterline, and have a displacement of 160,000 tons. It would contain quarters for 112 operating personnel, a crew roughly the size of that of some nuclear submarines. Each FNP, with a four-loop pressurized water reactor and steam supply system, would have a generating capacity of 1150 megawatts.

Normally, two or more FNP's would be moored together in water of from 40 to 70 feet deep. They would be protected by a massive breakwater from storms and from ships that might stray off course. The breakwater, forming an envelope that covers about 100 acres, would encircle the FNP's completely except for two relatively narrow openings to permit the free circulation of seawater and allow service vessels to enter.

The FNP sites must, at present, be within U.S. territorial limits, which extend 3 miles from shore. One reason for this is that the Price-Anderson Act,



The nuclear installation planned by a New Jersey utility. The two floating units would be built in Florida and towed to this site near Atlantic City.

which in the case of a nuclear accident would limit the liability of private insurers and the government to a total of $560 million, generally applies only to accidents occurring within the United States.

A FNP located even 2 to 3 miles offshore offers certain clear advantages over land-based plants in terms of day-to-day environmental effects and public safety.

A land-based plant may preempt a sizable area—indeed, at its Turkey Point plant below Miami, the Florida Power and Light Company has built a harp-shaped grid of cooling canals that covers more than 6000 acres. Cooling towers are not especially demanding of land, but they too exact certain penalties, as in the very power required to operate them. If, on the other hand, closed-circuit cooling is not provided for a plant on a river, lake, or estuary, the thermal effects on the aquatic biota can be disastrous.

With the FNP, this dilemma is at least partly avoided because "once-through" cooling with seawater can be employed without affecting a lagoon-like estuary or other confined body of water. The temperature of the cooling water drawn through the FNP would be raised by 16°F, but, outside the plant, the temperature rise would be confined to a relatively few acres. Many small organisms such as fish eggs, larvae, and plankton would be killed by entrainment through the cooling system, but these forms are generally less abundant in the open sea than in biologically fecund estuarine waters.

In the case of existing nuclear plants, their surrounding "exclusion area," where no human habitation is allowed, is reported to be seldom greater than ½ mile. Typically, the FNP would have an exclusion area of at least 2 or 3 miles wide, and, as will later be commented upon further, there seems no reason why—given the right legislative and engineering remedies—this area should not be much wider still.

The inception of the OPS is traceable to difficulties the Public Service Electric and Gas Company of New Jersey (PSE&G) began to encounter a few years ago in finding acceptable nuclear plant sites. This utility, together with certain other utilities in the mid-Atlantic region with which it shares electricity, foresaw a need to have eight nuclear units operating by the mid-1980's. But new environmental policies and regulations, such as those mandated by the National Environmental Policy Act of 1969 and the Water Quality Act of 1970, could make it impossible to obtain government permits for power plants that would be in densely inhabited areas or that would degrade water quality or encroach heavily on coastal or riverine wetlands or beaches.

Indeed, as the full implications of these new policies unfolded, PSE&G would, in 1973, abandon plans to build two nuclear units on Newbold Island in the Delaware River, in the densely urbanized region between Philadelphia and Trenton. The utility would adopt the alternative, recommended by the AEC regulatory staff, of building these units—at an added cost of some $60 million—in a rural area near Salem, N.J., where PSE&G already has two other nuclear units that will go on the line within the next few years. (According to Ralph Nader, the site of the existing Salem units, 18 miles from the center of Wilmington, Delaware, is itself out of keeping with "safe-siting guidelines" prepared by the AEC regulatory staff but never made public.)

In 1970, PSE&G asked Westinghouse, builder of the reactors for the first two units at Salem, to study the concept of offshore plants. This led to the 1971 announcement by Westinghouse and Tenneco of plans for their joint venture, OPS. By early 1972, PSE&G had given OPS a letter of intent to buy the first two FNP's produced, and this was later followed by the negotiation of a firm contract (subject to adjustments reflecting rises in the cost of labor and materials) for the delivery of these units at a price of about $375 million apiece, or $750 million for the two.

These first FNP's would be moored 2.8 miles off the New Jersey coast, at a point 12 miles northeast of Atlantic City and some 4 miles from the nearest resort village. PSE&G is responsible for constructing the breakwater and installing the underwater transmission cable by which power will be delivered to the mainland. The estimated total cost to PSE&G of the two FNP's is usually put at about $1 billion. The actual cost may depend to no small degree on what special safety features the AEC requires as a condition of licensing. But PSE&G is sanguine enough about ultimate costs to have recently ordered two more FNP's, which the company believes can be bought and put in service at a price that compares favorably to that of land-based nuclear plants. These units are not necessarily destined for an open ocean site, however. PSE&G has indicated that the FNP's may be placed at some inshore location instead, possibly in Delaware River or Bay.

OPS has been unable to start building its FNP manufacturing facility at Jacksonville until now because of delays in obtaining the necessary dredge and fill permits. It was not until 29 January that a U.S. District Court dismissed the Florida Audubon Society suit. Audubon apparently will appeal, but OPS officials have been confident enough about the outcome of the case already to have ordered the giant, $13-million gantry crane and even the fabricated steel for the first FNP hulls.

Besides believing that nothing will arise now to block construction of the production facility, OPS is counting on the AEC to issue a license by the spring of 1975 for the manufacture of FNP's

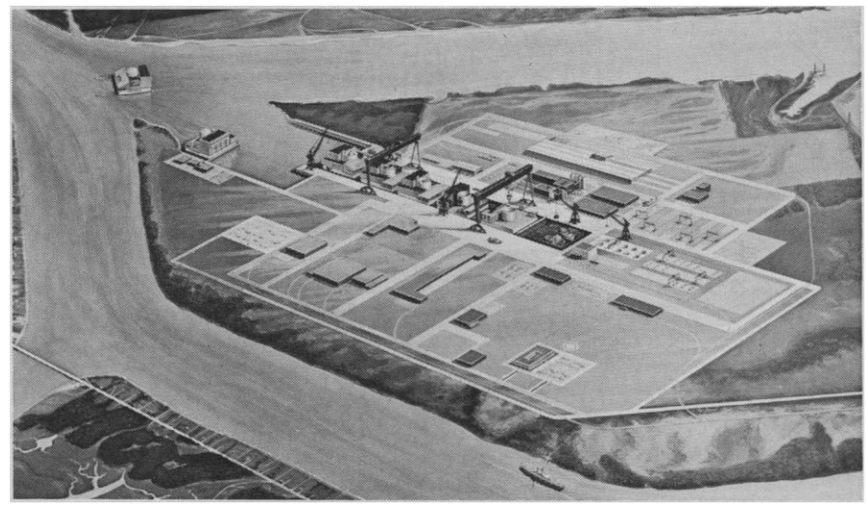
(the pending OPS application for a manufacturing license is for eight FNP's, but company officials say the number applied for will soon be raised to 16). If the license is in fact forthcoming without delay the OPS schedule calls for delivery of the first FNP in 1979 and of the second in 1980.

Once completely equipped and in full operation, the OPS facility would turn out four, or possibly five, FNP's a year. Manufacturing time per unit is expected to decline from 50 months for the first FNP to 26 months for the eighth one as labor efficiency and production techniques improve. Standardization and assembly-line methods would be the secret to this achievement, which would be dazzling indeed compared to the minimum of 60 to 72 months generally required to build large nuclear plants.

OPS is interested in eventually establishing manufacturing facilities to serve markets on the Pacific Coast, along the Great Lakes, and abroad. Delivery of FNP's from Jacksonville to the West Coast would not be practicable and has never been contemplated.

Thus far, the only firm orders OPS has in hand are those for the four FNP's that PSE&G is buying. The municipally owned Jacksonville Electric Authority has given OPS a carefully hedged letter of intent to order two FNP's. Middle South Utilities, a holding company in New Orleans, also has under serious consideration the possibility of ordering two (in this instance, the FNP's would not be moored offshore, but well up the Mississippi River, below Baton Rouge). Most utility officials are content for PSE&G to be the first to put the FNP concept to a practical test.

The AEC has, for its part, been generally supportive of the OPS project. John F. O'Leary, the AEC's director of licensing, has stated that, to judge from preliminary plans, the FNP concept is "feasible." The fact that the agency has even agreed to entertain an application for a *manufacturing* license is itself an innovation, for in the past the construction of a nuclear plant could only be licensed on the site where the facility would be built and operated. A licensing procedure covering a number of nearly identical plants under construction simultaneously in a single shipyard-like facility would permit the AEC to carry out a more efficient and intensive program of inspections than anything seen in the past. The utility buying a FNP also gains an advantage from this kind of licensing procedure. Even as the FNP is being manufactured, the utility applies to the AEC for an operating license and for permission to build the necessary breakwater.



The Offshore Power Systems manufacturing facility to be built at Jacksonville. The floating nuclear units would be assembled in the wet slipway.

"I don't think there's any doubt but what they [OPS] will get the [manufacturing] license if they are willing to put in all the features we may require," says Edson G. Cook, deputy director of licensing at AEC. "What they are gambling on is that the things required won't cost so much that it [the FNP] won't be economic."

The AEC's requirements will be established partly on the basis of highly detailed environmental reports. One such document required of OPS is a "generic" report on the FNP as installed and operated at various typical offshore sites. The report required of the purchasing utility has to do with the plant in relation to conditions at specific mooring sites.

Reactor Safeguards Committee

Last October, the AEC's Advisory Committee on Reactor Safeguards (ACRS) made a "pre-application site review" at PSE&G's request. From the committee's comments, one gets an inkling of the possible complications OPS and its customers may have to overcome. For instance, the ACRS, although it might dismiss Henry Kendall's fears as to the possibility of a reactor-core meltdown accident as exaggerated, seems at one with Kendall in its concern that such an accident might poison the sea over a wide area.

The committee observed that "further work is needed on the dispersal characteristics of fission products and plutonium which might be released" in the "highly unlikely" event of a fuel-melting accident. It even suggested that a completely closable breakwater, possibly employing locks, be considered as a safeguard against fires (as might be associated with the wreck of an oil or liquefied natural gas tanker), high waves, or the meltdown of a reactor core.

It is curious that, even as the FNP project raises a threat of contamination of the marine environment, its potential for lessening the threat from any release of plutonium or fission products to the atmosphere is reduced by the requirement that FNP's be moored within the 3-mile territorial limit. The desirability of removing this restriction would seem to add further justification for the current interest in extending the territorial limit. The possibility of siting the FNP at remote distances from urban areas may be the single most important advantage peculiar to such plants.

If truly remote sites should be used, water depths often might be so great as to make the construction of conventional breakwaters infeasible. Yet, even now, OPS is working on the concept of a floating breakwater for possible use along the Pacific Coast, where the continental shelf is extremely narrow.

In the event William Simon's vision of FNP's being used in large numbers at home and abroad is to be pursued, needless legal or engineering obstacles to making them as safe as possible should not be allowed to stand.

—LUTHER J. CARTER

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