Nuclear production costs increase

Over the past decade, the average lead time for construction of a U.S. nuclear plant has doubled, from 60 months to 120 months, as regulation requirements and environmental obstructions have delayed the process of putting power plants on line. (The 1985 DOE Nuclear Energy Cost Data Base puts the lead time for seven plants due for completion in 1984 at 165 months, with a construction duration of 130 months.) At the same time, the capital cost per plant has soared, rising faster than the rate of inflation. Today, the total capital cost of a nuclear plant of 1,000 MWe ranges from $2-5 billion, most of which is related to increased costs from time delays and changes required by additional NRC regulations. If the present trend continues, one source estimates, "by 1988, more than 50% of total plant cost will be time charges, and the nuclear island [the actual reactor] will cost only 10% of the total investment." (See **Figure 1**.)

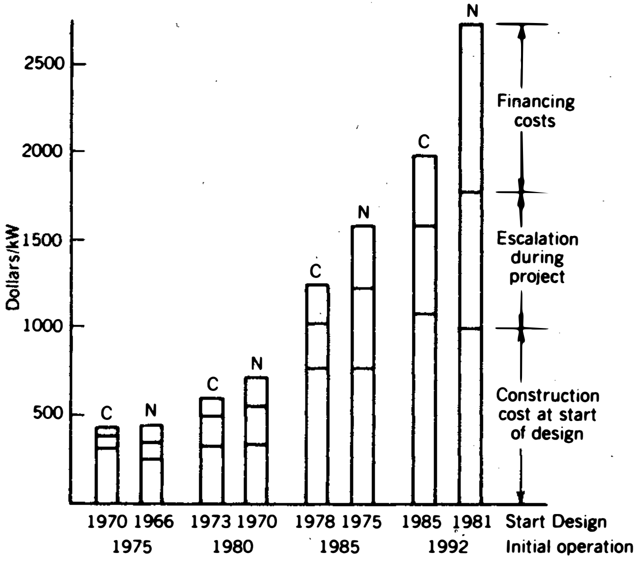
According to the Office of Technology Assessment's 1984 report, in the early 1970s, nuclear power plants were completed for a total cost of about $150 to $300 per kilowatt, while in 1983, seven nuclear power plants ready to come online cost from $1,000 to $3,000 per KW, an increase of 550 to 900%. General inflation alone would account only for an increase of 115% from 1971 to 1983, while inflation on components—labor and materials—would account for a further increase of about 20%, according to the OTA. The DOE Nuclear Energy Cost Data Base report shows the total costs of a typical 1,000 MW nuclear plant in January 1984 dollars to be $5,220 per kilowatt based on the average experience and $2,985 per kilowatt based on the best experience.

The EPRI report says that "the major cause of nuclear construction delays is the regulatory ratcheting phenomenon, which results in plant redesign, rework, and backfitting. Direct increases in labor and materials requirements, or deliberate delays by the owner utilities, have each contributed 20% or less to the total measured lead time delay. It is thus estimated that the combination of various regulatory ratcheting measures, and the utility's ability to respond to the required changes, are the major causes of the increasing plant lead times and capital costs."

A look at the breakdown of current costs in **Figure 2** gives a vivid idea of how the increased cost of a nuclear plant is *not* directly related to the nuclear island. Material costs have increased as a result of NRC regulations. For example, in 1971, an average plant needed 2,000 feet per MW of cable; now, 5,000 feet per MW are required. Similarly, in the late 1970s, the NRC revised seismic regulations, which increased

FIGURE 1

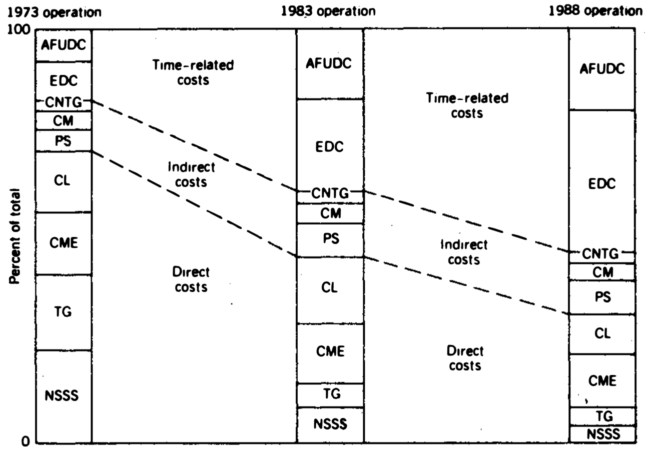
Capital cost components, typical U.S. generating plants



key: N—nuclear; C-coal with sulfur removal
Source: Electric Power Research Institute

FIGURE 2

Shifts in distribution of nuclear power plant capital costs.



Key:
NSSS—nuclear steam supply system; TG—turbine generator; CME—construction material and equipment; CL—craft labor; PS—professional services; CM—construction tools and material; CNTG—contingency; EDC—escalation during construction; AFUDC—interest during construction

the demands on the piping systems, so that pipe supports that cost several hundred dollars, have been replaced with very sophisticated restraints called "snubbers" with shock-absorbers, costing many thousands of dollars. Also, structural steel supports now cost between two and three times the cost of the same quality steel supports used for general construction which were used on nuclear plants until 1975. The EPRI study shows how there has been a doubling and tripling of the amount of electrical and other commodities required per plant—concrete increased 64% from the late 1960s to the 1970s, pipe increased 72%, and wire increased 100%. The unit prices of these commodities have also increased from four to eight times in this period. Many of the increased costs are the result of extensive modifications the plants had to undergo when they were partially completed, because the regulations were revised in midstream.

With the increase in regulations, came an increase in manpower needs. Whereas in 1967, a nuclear plant came online with an average of 3.5 construction manhours per kilowatt of power, in 1982-1985, 21.6 manhours per kilowatt were required. Nonmanual field and engineering labor increased from 1.3 manhours per kilowatt in 1967 to 9.2 manhours per kilowatt in 1980. The EPRI study points out that "the fastest increasing component of total costs in the last three years has been the cost of noncraft labor, which includes all engineering and supervisory manhours. The cost of engineering services for a nuclear plant completed by 1990 will be higher than the total capital cost of a plant completed in 1970, even when measured in constant dollars."

An interesting comparison is France, where total manhours required per kilowatt are half those of the United States. Unlike the United States, which has four nuclear reactor suppliers, several architect-engineering firms, and plant designs that depend on the particular specifications of the utility, France has standardized two types of reactors—925 MW and 1,300 MW. Also, in terms of time, the French put the Superphenix on-line in eight years. This is the first cial-size liquid metal fast breeder, an enormous construction effort, built in half the time it takes the United States to put an ordinary light water reactor on line.

Smaller plants more reliable

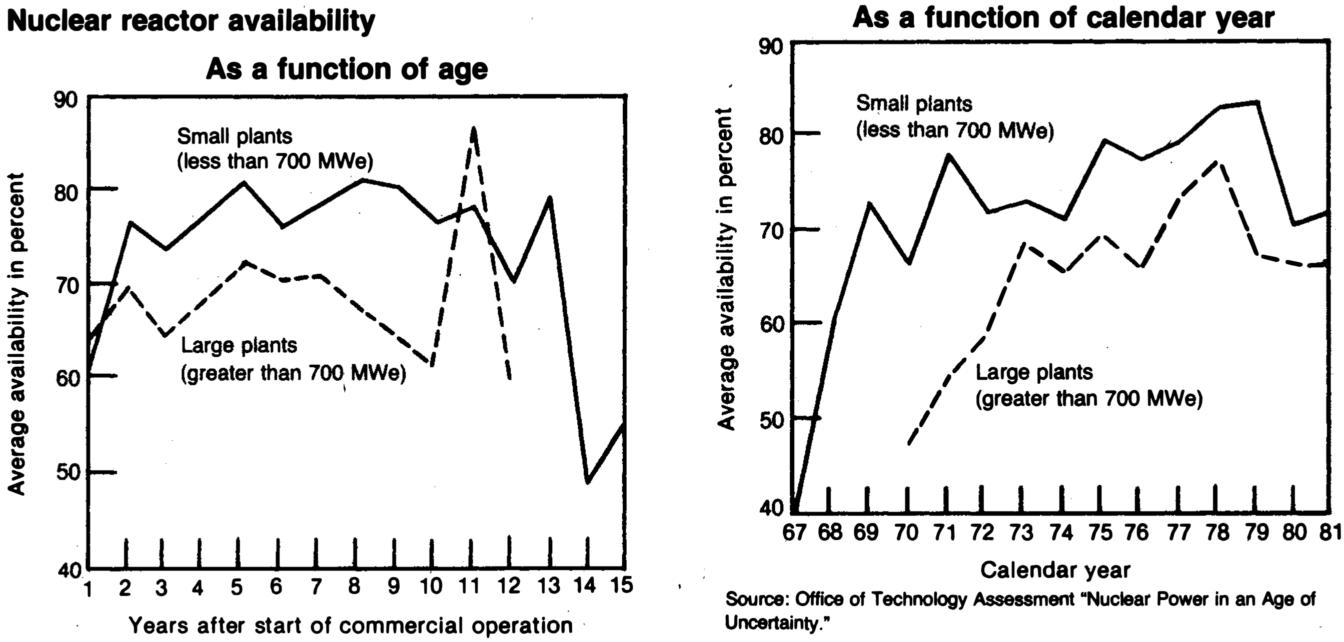
Figure 3 compares small and large plants on the basis of reactor availability, first as a function of age and second by calendar year. The smaller plants, in this case smaller than 700 MW, have at least a 5% greater availability.

The obvious advantages for smaller, modular plants are that this gives utilities greater flexibility (they can put additional power on-line in smaller amounts, which coincide with the low growth projections), the initial investment is smaller, factory fabrication is possible, and management for routine malfunctions or accidents is easier.

As in the Argentine CAREM project, smaller reactors allow for the standardized, factory production of reactors, and therefore allows the producer to create a trained workforce which remains at one worksite, greatly improving quality control at any given level of skills of the workforce generally.

FIGURE 3

Nuclear reactor availability



Source: Office of Technology Assessment "Nuclear Power in an Age of Uncertainty."