Chapter 2

Summary

Photo *credit: Department of Energy*

Oconee nuclear units owned by Duke Power Co.

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THE UNCERTAIN FINANCIAL AND ECONOMIC FUTURE

Future orders for nuclear plants depend in part on electricity demand and on the financial comparisons that utilities will make with alternatives to nuclear power. Utilities ordered far more generating capacity in the early 1970's than they turned out to need, and have canceled many of their planned plants. Nuclear plants have borne the brunt of the slowdown in construction.

There has been a pronounced decline in the growth rate of electricity demand. Demand growth has averaged about 2.5 percent annually since 1973, compared to about 7.0 percent from 1960 to 1972. Utility executives contemplating the construction of long leadtime coal or nuclear powerplants must contend with considerable uncertainty about the probable future growth rates in electricity demand. With certain assumptions about the future, it is reasonable to expect fairly slow growth rates of 1 to 2 percent per year. Very few large new powerplants would be required to meet this demand. With other plausible assumptions, electricity load growth could resume at rates of 3 to 4 percent per year, which would require the construction of several hundred gigawatts* of new powerplants by the year 2000. The actual need for new powerplants will depend on the growth rate of the economy, the rate of increase in the efficiency of use of electricity, price increases for electricity vis a vis other energy sources, new uses for electricity, and the rate of retirement of existing plants. None of these variables can be predicted with certainty. The effects of the electric growth rate and the replacement rate on the capacity that would have to be ordered in time to be completed by 2000 are shown in table 1.

in addition to the slowdown in electric load growth, powerplants have also been canceled and deferred due to deterioration in the financial condition of utilities. Although the industry's financial picture is improving as external financing needs decline and allowed rates of return increase, current rate structures still may not provide adequate returns for new investment in large nuclear projects. **Without changes in rate regulation, utilities may not be able to attract capital when they need it for construction, because investment advisers associate construction with a deterioration in financial health.**

The primary targets for rate reform include the current lag between allowed and earned rates of return, the "rate shock" which results in the first few years after a large, capital-intensive plant is added to the rate base, and the absence of explicit incentives to reduce fuel costs. Options for resolving these problems assume that the investors and State public utility commissions will take a long-term perspective and will maintain a particular method of determining revenue requirements for several decades. Yet when commissioners may only remain in office for a few years, or when State legislatures adopt a short-term perspective, methods that take a long-term view of rate regulation are difficult to achieve.

Table 1.–Additional Capacity Required by 2000 (gigawatts)

Levels of replacement of existing plants	Electricity demand growth 1.5%/yr	2.5%/yr	3.5%/yr
Low: 50 GW to replace all plants over 50 years old	9	144	303
Moderate: 125 GW to replace all plants over 40 years old, plus 20 GW of oil and gas capacity	84	219	379
High: 200 GW to replace all plants over 40 years plus two thirds of the oil and gas capacity	159	294	454

NOTES: 1. Planned generating capacity for 1991 is 740 GW, 158 GW more than 1982 generating sources of 582 GW. Starting point for demand calculations Is 1982 summer peak demand of 428 GW.
2. The calculations assume a 20-percent reserve margin, excess of planned generating resources over peak demand.

SOURCE Office of Technology Assessment

*One gigawatt equals 1000 MW (1 ,000,000 kW) or slightly less than the typical large nuclear powerplant of 1100 to 1300 MW.

Although ratemaking changes to increase the attractiveness of capital investment would eliminate some disincentives, utilities and their investors and ratepayers would still face substantial financial risks from nuclear power. These risks include the unpredictability of the capital costs of a nuclear plant at the beginning of construction, the difficulty of predicting construction leadtimes, the very high costs of cleanup and replacement power in the event of a major accident, and the possibility of future regulatory changes.

Nuclear plant average construction costs more than doubled in constant dollars during the **1970's** and are expected to increase by another 80 percent for plants now under construction. Some of this increase has come from new regulatory requirements which are applied to all plants, whether operating or under construction. Some utilities, however, have adapted better to these new regulatory conditions, as shown by the increasing variability in capital costs. Of the group of plants now under construction, the most expensive is expected to cost more than four times the least expensive. The variation in cost has been due in part to regional differences in the cost of labor and materials and the weather, **but more to differences in the experience and ability of utility and construction managers. Only the best**

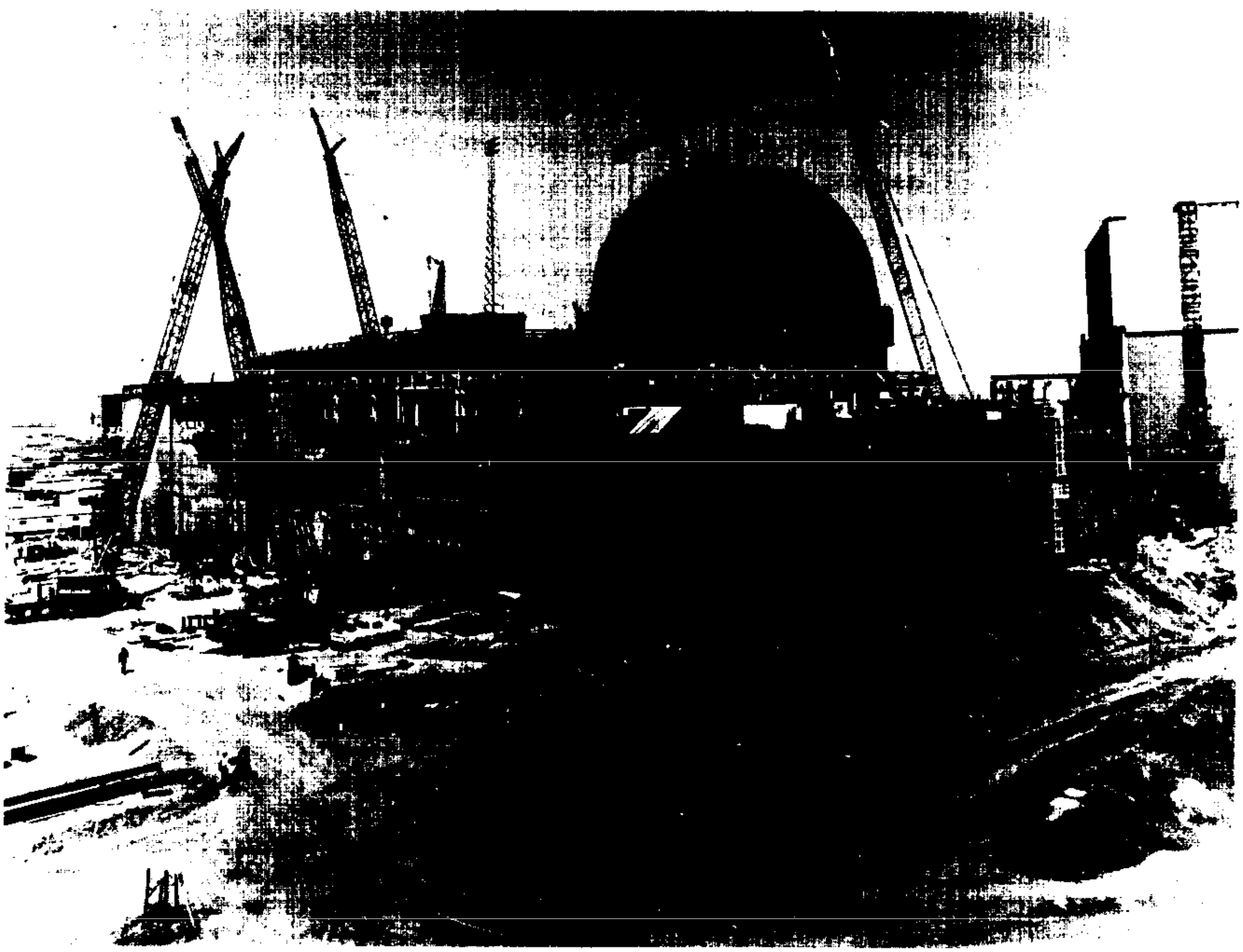


Photo credit: United Engineers & Constructors

Managing a multibillion dollar nuclear construction project is difficult, complex, and subject to uncertainty. The most expensive nuclear plant under construction is estimated to cost about four times the least expensive (per unit of generating capacity)

managed construction projects are now competitive with new coal plants.

Average nuclear plant construction leadtimes doubled over the decade (from about 60 to about 120 months) and are now about 40 percent longer than coal plant leadtimes. Very long leadtimes increase interest costs and the difficulty of matching capacity with demand. **Average plant construction costs and leadtimes could be reduced in the future in several ways:** 1) Plants could be built only by experienced and competent utilities and contractors, who would work under contracts with incentives to control costs and use innovative construction techniques. 2) Standardization of design and licensing could bring the lowest U.S. construction costs down by another 20 to 25 percent. 3) Further reductions in plant carrying costs could come about if leadtimes were cut by 25 to 30 percent and interest rates were reduced. It should also be recognized, however, that there are circumstances under which costs might increase. In particular, further serious accidents or resolution of important safety issues could lead to a new round of costly changes.

Utility executives are also aware that single events could occur causing the loss of the entire value of a nuclear plant. The accident at Three Mile island will have cost the owner $1 billion in cleanup costs alone, plus the cost of replacement power, the carrying costs and amortization of the original capital used to build the plant, and the cost of restarting the plant (if possible). Only $300 million of the cleanup cost was covered by property insurance. Nuclear plants can also be closed by referenda such as the narrowly defeated vote in 1982 that would have closed Maine Yankee.

Utility executives have other options to meet future load growth than constructing new generating plants including: converting oil or gas plants to coal, building transmission lines to facilitate purchase of bulk power, developing small hydro, wind or cogeneration sources, or load management and energy conservation programs. Some of these alternatives may prove more attractive to utilities than nuclear plants given the uncertain demand and financial situation. Even if rate regulatory policies across the country were to shift to favoring longer leadtime capital-intensive technologies, smaller coal-fired powerplants would be preferred because they have shorter leadtimes, lower financial risk, and greater public acceptance than current nuclear designs.

NUCLEAR REACTOR TECHNOLOGY

Virtually all nuclear powerplants in this country and most in other countries are light water reactors (LWRs). This concept was developed for the nuclear-powered submarine program, and was adapted to electric utility needs. Since then, many questions have been raised over the safety and reliability of LWRs in utility service, costs have risen dramatically and regulatory requirements have proliferated. There is no specific indication that LWRs cannot operate safely for their expected lifetimes, but it appears that current LWR designs are unlikely to be viable choices in the future unless concerns over costs, regulatory uncertainties and safety can be alleviated. Either LWR designs will have to be upgraded, or alternative reactor concepts will have to be considered.

There is no standardized LWR design in the United States. This is due to two major factors. First, the different combinations of vendors, architect-engineers (AEs), constructors, and utilities produced custom-built plants for each site. In addition, the reactor designs themselves have changed greatly since introduction of LWR technology. The pace of development from prototype to nearly 100 commercial reactors was very rapid. Large, new reactors were designed and construction started prior to significant operating experience of their predecessors. As hardware problems developed or new safety issues surfaced, changes had to be made *to existing reactors*, rather than integrating them into new designs, As regulatory agencies improved their understanding of nuclear power safety, criteria changed, and many features had to be mandated as retrofits. Thus the light water reactors under construction and in operation today do not represent an optimized LWR design.

Utilities' experience with the LWR range from excellent to poor. Some reactors have operated at up to an 80-percent capacity factor for years with no significant problems, while others have been plagued with continual hardware problems that lead to low-capacity utilization. While the safety record to date is very good, the accident at Three Mile Island (TMI) and other potentially severe incidents raise concerns about the ability of all utilities to maintain that record.

Many of the concerns over safety and reliability have been fueled by the seemingly constant stream of hardware problems and backfits associated with LWRs. Many of those in the nuclear industry feel that such problems reflect normal progress along the learning curve of a very complex technology, and they assert that the reactors are nearing a plateau on that curve. Nuclear critics observe that there are still many unresolved safety issues associated with LWRs, and the technology must continue to change until these are addressed adequately.

The design and operation of LWRs has unquestionably improved over time. The training of operators has been upgraded, human factors considerations have been incorporated into control room design, information on operating experience is shared, and numerous retrofits have been made to existing reactors.

Whether these steps have made LWRs safe enough cannot be demonstrated unambiguously, however. There is no consensus on how to determine the present level of safety, nor on the magnitude of risk represented by particular problems or the cost-benefit criteria for assessing possible solutions. In some cases, retrofits in one area can possibly reduce safety in other areas, either because of unanticipated system interactions, or simply because the additional hardware makes it difficult to get into part of the plant for maintenance or repairs. Even if all the parties to the debate could agree that the risks are acceptably small, the public still might not perceive nuclear power as safe.

It is clear that, before they order new nuclear plants, utilities will want assurances that the plants will operate reliably and will not require expensive retrofits or repairs due to unanticipated design problems or new Nuclear Regulatory Commission (NRC) regulations which may be needed to solve such problems, and that they will not run an unacceptable risk of a TMI-type accident that could bankrupt them.

Many of the nuclear industry's concerns about the current generation of LWRs are being addressed in designs for advanced reactors. An advanced pressurized water reactor is being designed to be safer and easier to operate than the present generation, and to have improved fuel burnup and higher availability (90 percent is the goal) through resolution of some of the more critical hardware problems. An advanced boiling water reactor is being designed to operate at a relatively high capacity factor and to incorporate advanced safety features that will reduce the risk of core-melting even if the primary cooling system fails.

If the utilities and the public cannot be convinced that new LWRs would be acceptably safe and reliable, however, renewed interest may develop in using alternative reactor technologies. Among the more promising near-term possibilities are high temperature gas-cooled reactors, LWRs with inherently safe features, and the heavy water reactor.

The high temperature gas-cooled reactor (HTGR) has attracted considerable interest because of its high thermal efficiency (nearly 40 percent—compared to 33 percent for an LWR) and its inherent safety features. The core of the HTGR is slow to heat up even if coolant flow is interrupted; this reduces the urgency of the actions that must be taken to respond to an accident. In addition, the entire core and the primary cooling loops are enclosed by a vessel which would prevent the release of radioactive materials even after an accident. Lessons learned on the only U.S. operating HTGR are being applied to the design of a 900-megawatt (MW) prototype. Small, modular versions (fig. 1) also have been proposed that might have very attractive safety characteristics and be especially suitable as a

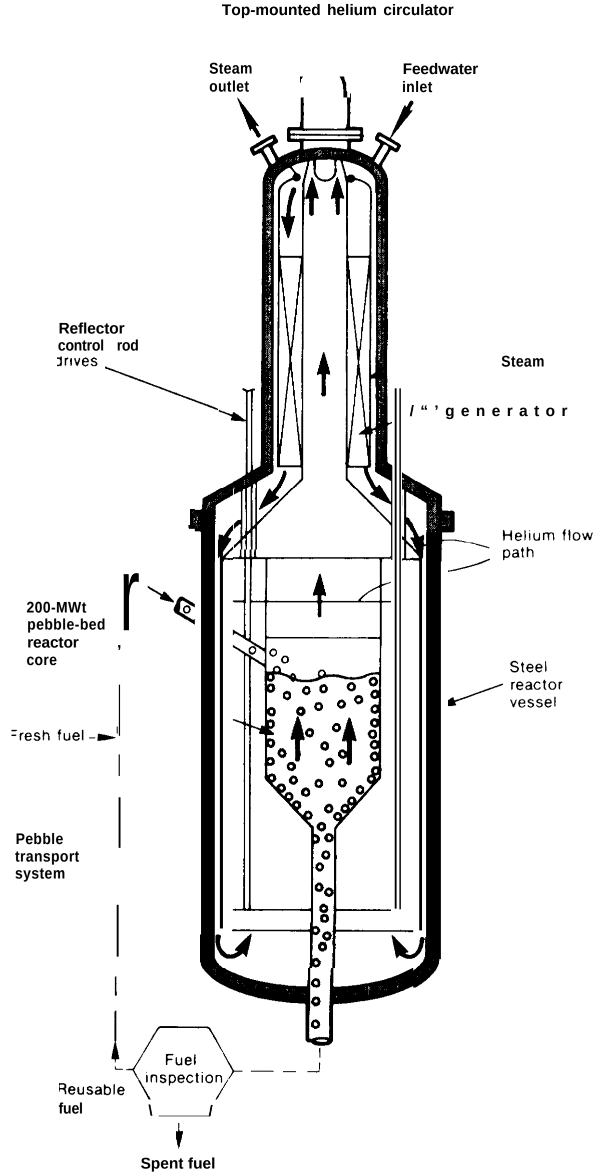
Photo credit: Gas-cooled Reactor Associates (GCRA)

The fuel in a high temperature gas-cooled reactor is inserted into graphite blocks like the one shown above. The fuel form is one of the key features of the HTGR, since graphite can absorb a great deal of heat before melting

source of process heat. While HTGRs appear to be potentially safer than LWRs, there are still many questions concerning HTGR reliability and economics. **Continued research and development (R&D) of the HTGR is necessary if these questions are to be resolved.**

The heavy water reactor (HWR) has attractive safety and reliability features, but there are several roadblocks to its adoption in this country. The HWR has performed well in Canada, but the process of adapting it to the American environment might introduce modifications which would lower its performance. In addition, much of its good performance may be the result of skillful management and not a consequence of the reactor design. Without significant evidence that the reactor is inherently superior to other options, the HWR is not a strong candidate for the U.S. market, unless the Canadian technology can be easily adapted, or the U.S. experience with HWRs in the weapons program can be utilized.

Figure 1.—Conceptual Design of a Modular, Pebble-Bed HTGR



SOURCE: Office of Technology Assessment.

The process inherent ultimately safe (PIUS) reactor, a new LWR concept being developed in Sweden, is designed with safety as the primary objective. protective against large releases of radioactivity would be provided by passive means that are independent of operator intervention and mechanical or electrical components. Because the PIUS is designed so that a meltdown is virtually impossible, it might be the reactor most suited to restoring public confidence in nuclear power. The PIUS reactor is still in the initial design phase, however, and has not yet been tested, although computer simulations have been initiated to address questions about operational stability. Extensive R&D is needed to narrow the uncertainties about cost, operation, and maintenance. This R&D and eventual deployment of the PIUS, would be expedited by its similarity, in some respects, to conventional LWRs.

Features that might be applied to any reactor technology include smaller sizes and standardized designs. **Smaller nuclear plants would provide greater flexibility in utility planning—especially in times of uncertain demand growth—and less extreme economic consequences from an unscheduled outage.** The shorter construction periods and lower interest costs during construction would reduce the utilities' financial exposure. The ability to build more of the subsystems in the factory rather than onsite might reduce some construction costs, offsetting the lost economies of scale. Moreover, smaller reactors **might** be easier to understand, more manageable to construct, and safer to operate. Federal R&D would probably be required to achieve designs that exploit the favorable characteristics of small reactors.

The potential benefit of a standardized design appears to be especially high in view of the problems of today's nuclear industry. **Many of the problems with construction and operation stem from mismanagement and inexperience, and a standardized plant would help all utilities learn from those who have been successful.** France and Canada seem to have done well with building many plants of one basic design. Still, the implementation of standardized plants in the United States faces many obstacles. Reactor system designs differ from vendor to vendor and grow further apart when coupled with the different balance of plant designs supplied by the numerous AEs. They are additionally modified by the requirements of NRC, the utilities, and the specific sites. **Despite these obstacles, the industry may be motivated to converge on one or two standardized designs if that path seemed to offer streamlined licensing, stabilized regulation, faster construction, and better management.** The help of the Federal Government may be required to develop and approve of a common design, especially if it is significantly different from the LWR.

MANAGEMENT OF NUCLEAR POWERPLANTS

The management of commercial nuclear powerplants has proven to be a more difficult task than originally anticipated by the early proponents of nuclear technology. While the overall safety record of U.S. plants is very good, there has been great variability in construction times and capacity factors (see table 2). Some utilities have demonstrated that nuclear power can be well managed, but many utilities have encountered difficulties, Some of these problems have been serious enough to have safety and financial implications. **Since the entire industry is often judged by the worst cases, it is important that all nuclear utilities be able to demonstrate the capability to manage their powerplants safely and reliably.**

There are many special problems associated with managing a nuclear powerplant. Nuclear reactors are typically half again as large and considerably more complex than coal plants. **The job of building and operating a nuclear powerplant has been further complicated by the rapid pace of development.** As new lessons were learned from the maturing technology, they had to be incorporated as retrofits rather than integrated into the original design. The regulatory structure was evolving along with the plants, and the additional engineering associated with changing NRC regulations and with retrofits strained the already scarce resources of many utilities. Some utilities have also had difficulty coordinating the various participants in a construction project.

Table 2.—Comparison of Construction and Reliability Records for Selected U.S. Light Water Reactors

Construction[a]	Date of commercial operation	Years to construct	Reliability[b]	Date of commercial operation	Lifetime capacity factor (%)
Best:			**Best:**		
St. Lucie 2	1983	6	Point Beach 2	1972	79
Hatch 2	1979	7	Connecticut Yankee	1968	76
Arkansas Nuclear One 2	1980	7	Kewaunee	1974	76
Perry 1	1985	8	Prairie Island 2	1974	76
Palo Verde 1	1984	8	Calvert Cliffs 2	1977	75
Byron 1	1984	8	St. Lucie 1	1976	74
Callaway 1	1984	8			
Worst:			Worst:		
Watts Bar 1	1984	12	Brunswick 1	1977	48
Sequoyah 2	1982	12	Indian Point 3	1976	46
Midland 1	1985	13	Salem 1	1976	46
Zimmer 1	1985	13	Brunswick 2	1975	41
Salem 2	1981	13	Davis Besse 1	1977	40
Diablo Canyon 2	1984	14	Palisades	1971	39
Diablo Canyon 1	1984	16	Beaver Valley 1	1977	34

[a]Includes only plants licensed t. operate after the accident at Three Mile Island in March of 1979
[b]Includes only plants greater than 100 MWe in operation for longer than [3] years.

SOURCE *Nuclear* News, February 1983 and U S Nuclear Regulatory Commission

Both technical and institutional changes are needed to improve the management of the nuclear enterprise. Technical modifications would be useful insofar as they reduce the complexity and sophistication of nuclear plants and their sensitivity to system interactions and human error. More substantial design changes, such as the **PIUS reactor concept, might be considered as an option** since they have the potential to additionally decrease the sensitivity of nuclear plants to variations in management ability.

Technological changes, by themselves, however, cannot eliminate all the difficulties involved in building and operating nuclear units since they cannot replace commitment to quality and safety. It **is important that design changes be supplemented with institutional measures to improve the management of the nuclear enterprise.** One example is the Institute of Nuclear Power Operations **(INPO),** * which is attempting to improve the quality of nuclear powerplant operation, and to enhance communication among the various segments of the industry.

***The Institute for Nuclear Power Operations is a self-regulatory nonprofit organization organized by the electric utilities to establish industrywide standards for the operation of nuclear powerplants, including personnel and training standards, and to ensure that utilities meet those standards.**

The most important improvement required is in the internal management of nuclear utilities. **Top utility executives must become aware of the unique demands of nuclear technology. They not only must develop the commitment and skills to meet those demands, but they must become directly involved in their nuclear projects and they must impress on their project managers and contractors a commitment to safety that goes beyond the need to meet regulatory requirements. They also need to establish clear lines of authority and specific responsibilities to ensure that their objectives will be met. INPO** could be instrumental in stimulating an awareness of the unique management needs of nuclear power and in providing guidance to the utilities.

It **is also important that utilities be evaluated objectively to assure that they are performing well.** Both NRC and INPO have recognized the **need** for such evaluations, and currently are engaged in assessment activities. INPO attempts to assess the performance of utility management in order to identify the root causes of the problems as well as their consequences. The **NRC** conducts several inspection programs with the purpose of identifying severe or recurrent deficiencies. NRC's program is more fragmented than IN PO's,

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and the relationships among its various inspection activities appear to be uncoordinated.

Enforcement activities also can be important in encouraging better management. Both NRC and INPO can take actions to encourage utilities to make changes or penalize them if their performance is below standard. If measures taken by NRC and INPO prove to be ineffective in promoting quality construction and safe operation of nuclear powerplants, however, more aggressive action might be required. A future for nuclear power could depend on institutional changes that demonstrate the ability of **all** utilities with nuclear powerplants to operate them safely and reliably. It is not yet clear whether these efforts will prove adequate.

Another approach might be for the NRC to require that a utility be certified as to its fitness to build and operate nuclear powerplants. Certification could force the poor performers to either improve their management capabilities, obtain the expertise from outside, or choose other types of generating capacity.

Many of the current management problems can also be traced to the overlapping and conflicting authority of the the utility, the reactor vendor, the AE, and the constructor. Centralized responsibility for overall design and, in some cases, actual construction could alleviate this problem. Increased vendor responsibility might encourage fixed-price contracts for nuclear plants, but it could detract from utilities' ability to manage the plant if they are not involved actively in all stages of construction.

A second means of centralizing responsibility is through nuclear service companies, which already offer a broad range of regulatory, engineering, and other services to utilities. **Nuclear service companies could help strengthen the capabilities of the weaker utilities by providing all the services needed to build and/or operate a nuclear plant.** However, utilities may be reluctant to forego their responsibility for safety and quality while retaining financial liability. Also, without some mechanism that required weaker utilities to hire service companies, their existence might have little effect on the overall quality of nuclear management.

Privately owned regional or national nuclear power companies would extend the service company concept into the actual ownership of nuclear powerplants. Such companies could be owned by a consortium of utilities, vendors, AEs, and/or constructors and would be created expressly to build and operate nuclear powerplants.

REGULATORY CONSIDERATIONS

Nuclear power is one of the most intensively regulated industries in the United States, and the scope and practice of regulation is a volatile issue, Strong—and usually conflicting—opinions abound among the actors in the nuclear debate on the adequacy and efficiency of the current regulatory system.

The utilities and the nuclear industry have been outspoken critics of the current system of nuclear plant regulation, claiming that neither the criteria nor the schedules for siting, designing, building, and operating nuclear plants are predictable under the current licensing scheme. They argue that public participation has been misused to prolong licensing hearings unnecessarily. They believe that these factors have been the primary cause of higher costs and longer construction leadtimes and may have been detrimental to safety.

Nuclear critics, on the other hand, have been less critical of Federal regulation of nuclear powerplants than of the industry that designs, constructs, and operates them. They argue that the lack of predictability and the increase in leadtimes were due to the immaturity of the technology and growing pains due to rapid escalation. They attribute many safety concerns to utility and constructor inattention to quality assurance, and inconsistent interpretation and enforcement of regulations within the NRC. While some critics feel that nuclear plants will never be safe enough, others believe that the current regulatory process could ensure safety if it were interpreted consistently and enforced adequately, but that limiting the opportunities for interested members of the public to participate in licensing will detract from safety.

As a result of these concerns, a number of modifications in reactor regulation have been proposed, either through legislation, rulemaking, or better management of the regulatory process. The primary targets of the various packages are backfitting, the hearing process, siting, and the licensing of designs and plants. **The evaluation of proposals for regulatory revision must depend first on whether they will ensure adequate protection of public health and safety and national security, and only secondarily on additional benefits, such as reducing the cost of nuclear plants. It is also important to recognize that licensing changes alone cannot resolve the problems of the nuclear industry. All parties to nuclear regulation must commit themselves to excellence in the management of licensing, construction, and operation, as well as to resolving outstanding safety and reliability issues.**

Many nuclear utilities are adamant that they will not order another reactor until licensing is more predictable and consistent. These characteristics should also be welcomed by the critics since they are prerequisites for uniformly high safety standards. The primary source of current uncertainty is the potential for imposition of backfits. Backfits serve an important safety function, since unanticipated safety problems do arise after construction permits are granted. **But careful revision of the backfit rule could make the process more rational and ensure that plant safety is not inadvertently decreased by installation or maintenance problems or by unexpected interactions with other systems.** Proposed changes to the backfit rule focus on making the criteria for ordering backfits more explicit, such as the use of cost-benefit analysis. **While a cost-benefit approach would "improve" consistency, it should not be used as the sole criterion since the available methodologies are inadequate to fully quantify safety improvements.** A process to review proposed backfits could also involve a centralized group either within the NRC or as an independent panel drawn from utilities, the public, and the nuclear industry to ensure that criteria and standards are consistently applied.

Legislative amendment of the Atomic Energy Act is not necessary to reform the backfit regulations, since the changes discussed above can be accomplished through rulemaking. Moreover, legislative definitions and standards may actually reduce flexibility needed to adjust to changing construction and operating experience. Legislative action would be more likely, however, to ensure predictability.

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Another issue in regulatory reform is the use of formal trial-type hearings in reactor licensing. Because adjudicatory hearings can be long and costly, proposals have been made to replace them with hybrid hearings, which would be more restricted. A hybrid hearing format might be attractive to the owners of nuclear powerplants, but it might also limit the opportunities for public inquiry and foreclose debate on safety issues. **The hearings could be made more efficient without changing the format if they were managed better. They could also be improved by making greater use of rulemaking to resolve generic issues and by eliminating issues not germane to safety. Only the last of these changes would require legislative amendment of the Atomic Energy Act.**

It has also been suggested that construction permits and operating licenses in the current system be combined into a single step to improve predictability and efficiency. One-step licensing, however, raises questions on how to manage outstanding safety issues and backfits during construction without any guarantee that the licensing process would not be even lengthier and more uncertain.

Two other proposals for changes to the current regulatory system would allow for binding preapproval of reactor designs and sites. Proapproval of standardized plant designs could make the licensing process more predictable and efficient by removing most design questions from licensing. It also raises new issues, such as the degree of specificity required for proapproval and the conditions under which a utility and its contractors could deviate from a preapproved design. Proapproval of reactor sites is a less controversial proposal. **As long as safety issues related to the combination of a site and a proposed plant are considered in subsequent licensing process, binding site approval would not detract from plant safety.** Moreover, it would contribute to shorter construction leadtimes since it would take siting off the critical path for licensing. This procedure, which is followed in France, Great Britain, and Japan, could even enhance public participation by encouraging in-depth analysis at an earlier phase.

SURVIVAL OF THE NUCLEAR INDUSTRY IN THE UNITED STATES AND ABROAD

The bleak outlook for nuclear power, at least in the near future, raises concern about the long-term viability of the nuclear industry in the United States and its ability to compete internationally.

Reactor vendors may remain busy for many years by providing operating plant services and fuel loading. These companies are also expanding their scope and competing with the service contractors for jobs. **However, in the absence of at least a few new-plant orders each year, the vendors will not survive in their present form.**

The AEs will also have substantial work finishing construction on plants now in progress, installing retrofits and dealing with special problems such as replacement of steam generators. The AEs may find additional activity by "recommissioning," or extending the useful life of older plants.

The companies that supply nuclear components may keep going by supplying parts for backfits and repairs, but their numbers are expected to shrink by two-thirds in the next 3 to 5 years. **Utilities will have increasing difficulty purchasing parts when needed and at expected costs.** The cessation of new-plant orders has already caused some shortages in parts and services needed by operating plants.

Shortages are also developing in some personnel areas. The industry has vacancies for health physicists and for reactor and radiation-protection engineers, but it has a surplus of design engineers. Enrollment for nuclear engineering degrees has declined since the mid-1970's, and the graduate levels will barely be enough to fill the anticipated need for 6,000 engineers for operation of plants by 1991, even if enrollments drop no more. **With no fresh orders, the industry is not likely to attract the best students.**

The ability of the nuclear industry to respond to an influx of new orders depends on the length of time before those orders arrive. **If utilities request new powerplants within 5 years, the industry could supply them, although perhaps with delays of a year or so to restart design teams and manufacturing processes. If the hiatus in plant orders lasts 10 years, the recovery would be slow and not at all certain-especially if U.S. vendors have not been selling reactors abroad in that period. In that case, U.S. utilities may have to buy components, if not entire powerplants, from foreign suppliers.**

Many of the problems that have beset the U.S. nuclear industry have hampered the nuclear industries abroad, but with less severe impact in general. Worldwide forecasts of the future role of nuclear power have experienced the same boom and bust that they have in the United States. West Germany, France, Japan, and Canada all are intending to compete with the United States in what is expected to be a very competitive international market for nuclear plants.

In most nations with nuclear power programs, the public has expressed some opposition. In several cases (e.g., Sweden), this has been strong enough to stop new plants from being ordered. All nuclear industries have experienced delays in building plants, but the costs have typically been lower. The licensing process in West Germany is as complex as that in the United States, but licensing in nations such as France is streamlined by strong government control and support and the use of standardized designs.

The efforts by the major reactor vendor in West Germany to standardize its plants might prove to be a useful model for the U.S. nuclear industry. The German vendor plans to produce a series of powerplants in groups of five or six whose standardized features will reduce delays, engineering workhours, and paperwork. Each series of standardized designs would build on the experience of the previous group of plants.

PUBLIC ATTITUDES ON NUCLEAR POWER

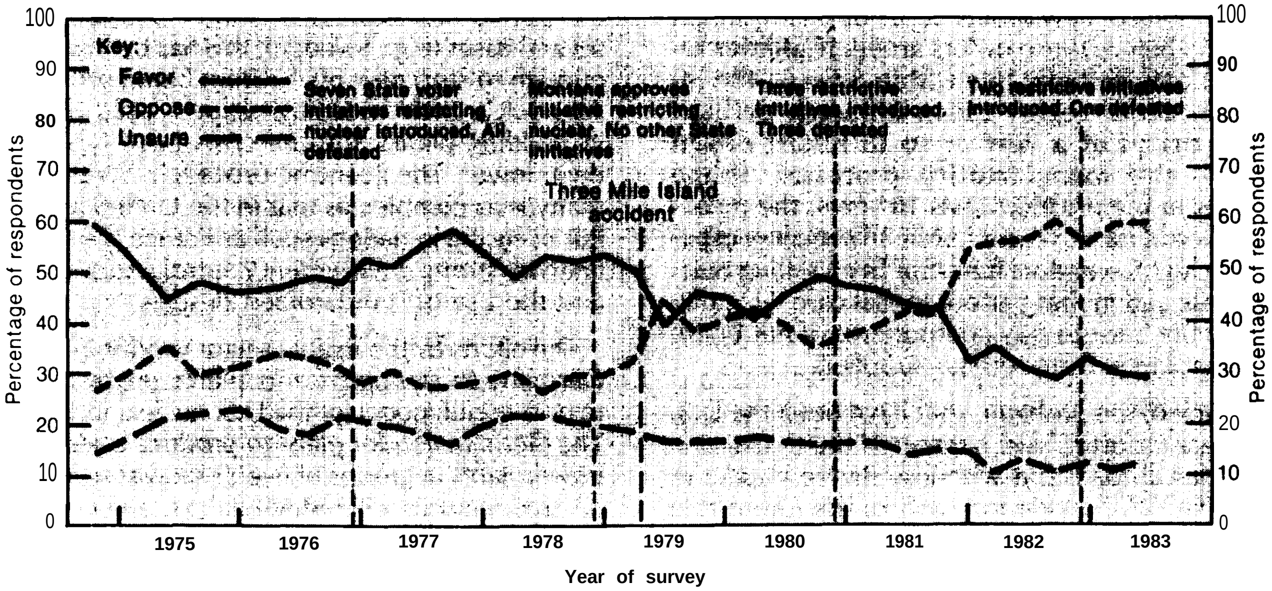
public attitudes towards nuclear power have become increasingly negative over the past decade, largely because of growing concern over safety and economics. The most recent polls indicate that only a third of the public supports construction of nuclear plants, while over so **percent are opposed (see fig. 2).**

Public support is an essential ingredient in any strategy for recovery of the nuclear power option. Negative public attitudes are most directly manifested through referenda. Although all binding referenda that would have shut existing plants have been rejected to date, some have been close. Referenda and legislation have been approved in 11 States that will prevent construction of any new nuclear plants unless prescribed conditions are met. Indirectly, public worry over nuclear risks has been a principal reason for NRC's imposition of safety backfits to existing reactors. State public utility commissions are unlikely to adopt rate structures favoring nuclear projects unless a majority of the public is in favor.

A central factor in public concern is the fear of a nuclear accident with severe consequences. Surveys indicate that most people view death due to a nuclear accident as no worse than other causes of death, but they fear nuclear plants because the technology is unfamiliar and foreboding. Much of the loss of public confidence is **a** result of a series of safety-related incidents at several reactors, especially the accident at TMI, and the evident mishandling of these incidents by utilities. **The likelihood of a catastrophic accident is perceived as greater than that estimated by safety analysts in industry and government, creating a credibility gap.**

Another factor in public concern about nuclear power is the ongoing debate about nuclear plant safety among scientists and other experts. As the public has listened to the experts debate, they have grown increasingly dubious about plant safety. If the experts cannot agree, the public concludes, then there must be a serious question about the safety of nuclear power.

Figure 2.—Trends in Public Opinion on Nuclear Power



Question asked” “Do you favor or oppose the construction of more nuclear powerplants?"
SOURCE: Cambridge Reports, Inc.

Concerns other than accidents have caused some people to turn away from nuclear power. Perhaps the largest concern after the possibility of an accident is the disposal of high-level wastes generated by nuclear reactors. In addition, the potential esthetic and environmental damage caused by nuclear plant construction also raises objections. Some groups see a link between the military and commercial applications of atomic power. Finally, distrust of large government and institutions has carried over, to some degree, to both the nuclear industry and NRC.

People are prepared to accept some risk if they see a compensating benefit. The high cost of some nuclear plants and current excess generating capacity, however, lead many to question if there is any advantage.

While media coverage of nuclear power has become more extensive in recent years, there is no evidence of overall bias against nuclear power. The spectrum of opinion among reporters is the same as that for the population as a whole. Their coverage is more likely to reflect than to determine society’s concerns.

The credibility of both the industry and NRC is low, so words and studies alone will have little impact on the public. Steps to improve public attitudes towards nuclear power must rely on an actual demonstration of the safety, economics, and reliability of nuclear power. If the reactors currently under construction experience continued cost escalation, the next generation will have to be much more economic to gain public support. Alternative reactor concepts that have inherent safety features, and studies of other energy sources, including analysis of the environmental costs and benefits, also might help change public attitudes, though other concerns such as over waste disposal would still remain.

One of the most important steps in reducing public fears of a nuclear accident would be to improve utility management of the technology. Improved management could greatly reduce the likelihood of accidents which the public views as precursors to a catastrophe. **While making every effort to minimize both minor incidents and more serious accidents, however, the nuclear industry should be more open about the possibility of accidents.**

Improved communications with nuclear critics might also alleviate public concerns about reactor safety. A concerted effort to identify and respond to the substance of critic's concerns could reduce acrimonious debate which contributes to negative public opinion.

POLICY OPTIONS

Further orders for nuclear powerplants are unlikely without some government action and support. If Congress chooses to improve the chances of nuclear reactors being ordered in the future, Federal initiatives could be directed to the following goals:

- reduce capital costs and uncertainties,
- improve reactor operations and economics,
- reduce the risks of accidents that have public safety or utility financial impacts, and
- alleviate public concerns and reduce political risks.

These general goals are neither new nor as controversial as the specific steps designed to achieve the goals. The initiatives discussed in this report that-are likely to be the most effective are:

1. **Support a design effort to re-optimize reactor designs for safety, reliability, and overall economy.** This initiative would extend the efforts of the reactor vendors. Designs would incorporate the backfits that have occurred in existing plants and address the outstanding safety issues, thereby significantly reducing the possibility of costly changes during construction and the concern for safety in current LWRs. It would be expensive, however, especially if a demonstration plant is necessary.
2. **Improve the management of reactors under construction or in operation.** Inadequate management has been one of the major causes of construction cost overruns and erratic operation. Efforts are underway by the NRC and INPO to upgrade reactor management, and they should show results in improved training programs, better quality control and more reliable performance. The congressional role in improving reactor management would be oversight of the NRC, and support for improvements in analytical techniques and resolution of the remaining safety issues.

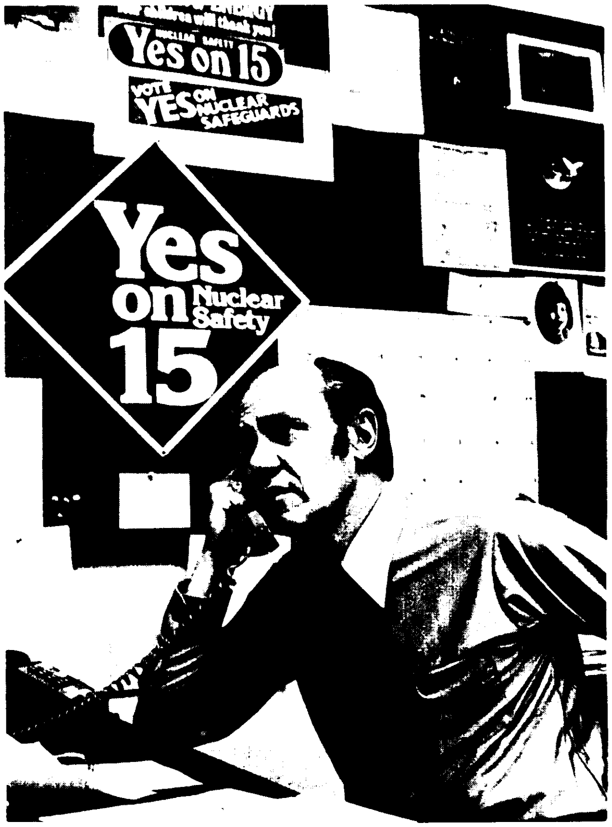


Photo credit: William J. Lanouette

This photo shows the campaign headquarters of the Project Survival Group which supported Proposition 15, a California referendum prohibiting further construction of nuclear plants without a definitive resolution of nuclear waste storage. The referendum was defeated in 1976, but a similar California law was recently upheld by the Supreme Court

3. **Revise the regulatory process.** Many of the difficulties experienced with licensing would be avoided with future plants through improved technology and management. Improving the predictability and efficiency of licensing is a prerequisite for any further orders, however. To a large extent this could be done administratively by the NRC without

legislation. Some of the elements such as consistent backfit evaluations and preapproval of reactor designs and sites discussed in the regulatory section above will probably require at least strong congressional oversight and possibly legislation. Legislation that makes the process inflexible or restricts public access could be counterproductive.

4. **Certify utilities and contractors.** If efforts to improve reactor management are only partially successful, stronger measures could be warranted. A poorly performing utility can affect the entire nuclear industry through the response of the public and the NRC to incidents with safety implications. The NRC might consider withdrawing the operating licenses of utilities that do not demonstrate competence or commitment in managing their nuclear plants. Evidence of capability of the utility and its contractors might be made a prerequisite for a new construction permit to alleviate concerns of the public, investors, and critics about the quality and cost of the plant.
5. **Support R&Don new reactors. Some new reactor concepts have features that, if proven out, could make them inherently safer than current operating plants, thus alleviating some of the concerns of the utilities and the public. If advanced LWRs do not appear adequate to overcome these concerns, then the availability of an alternative reactor,** such as the HTGR, would be important. Research, development, and demonstration of these technologies will be necessary to make them available.
6. **Address the concerns of the critics. Improved public acceptance is a prerequisite for any new orders. At present, the public is confused by the controversy over safety and is therefore opposed to accepting the risks of new reactors. The best way to reduce controversy would be to resolve some of the disagreements between the nuclear industry and its critics. This could be initiated by involving the critics more directly in the regulatory** process. Involving knowledgeable critics in regulation or in the design and analysis of new reactors may be the only way to assure the public that safety concerns are being addressed adequately.
7. **Control the rate of nuclear construction.** Many of the concerns over nuclear power originated from the early projections of rapid growth, and expectations of a pervasive "nuclear economy." The present modest projections appear less threatening, but some people will oppose all nuclear power as long as a major resurgence is possible. Controlling the growth rate might alleviate these concerns, thus reducing the controversy, rebuilding public acceptance, and making some new construction possible.

None of the options described above will be very effective by itself. Some could be very difficult to implement. It appears at least possible, however, that **combinations of these options could contribute to a much more favorable environment for nuclear power.**

Whether any of these strategies would "work" is a function of several factors including:

- the extent to which Federal policy strategies resolve the problems and make nuclear power more attractive,
- the electricity demand growth rate and the eventual need for new powerplants, and
- the improvement in designs and operations in the absence of policy initiatives.

The future of the nuclear industry will be shaped by the evolution of these factors. The degree to which the Federal Government should become involved (the first factor above) depends on an assessment of the uncertainties surrounding the other two factors. Under some conditions (e.g., relatively rapid growth in demand for electricity, reliable operation of existing plants and improved technology available) a revival is quite possible. Under other conditions, even a strongly supportive policy strategy could fail. Successful implementation of any strategy will depend on how well the concerns of all interested parties have been addressed.