Chapter 9

Policy Options

Photo credit: Ontario Hydro

Pickering nuclear station has four identical CANDU units built in 1973 and four more scheduled for completion in 1985. Standardization helped reduce construction costs and improve operator training

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INTRODUCTION

The previous chapters have painted an unpromising picture of the future of nuclear power in the United States. Projections for new central station generating capacity over the next 20 years are much lower than those of just a few years ago. The high financial and political risks involved with nuclear plants suggest that any central station capacity that is added would be coal-fired. Under existing conditions, there are few incentives for utilities to select nuclear plants and many reasons to avoid them.

It can be highly misleading, however, to forecast future decisions on the basis of existing conditions. Some of the problems that appear so formidable now will diminish. The plants under construction now were designed according to concepts developed 10 to 15 years ago. Any future plants can be expected to incorporate major changes that have been backfitted onto existing plants and other changes that have been suggested to improve operation. In addition, much has been learned about how to construct plants more efficiently, While these and other changes would go far toward eliminating the large cost overruns some utilities have experienced, they probably are not sufficient to restore confidence in the financial viability of the technology. Other concerns exist that these changes will not address. Therefore, it is probable that additional initiatives, including Federal actions, will be required if the country concludes that nuclear energy is to continue to grow past the plants now ordered.

As recounted in chapters 1 and 3, there are reasons why the Nation could decide that it would be in the national interest to maintain a domestic nuclear option. Nonfossil fuel energy sources may be urgently required for environmental reasons within several decades, and nuclear energy could be the most economical source that can be readily deployed. Even if such environmental conditions do not materialize, it could be economically prudent to retain a generating source other than coal. The energy outlook for the early 21st century, when oil and gas reserves will become seriously depleted, is very uncertain. If it is reasonably possible that nuclear power will be seen as very desirable or even indispensable within 20 or 30 years, it probably is more efficient to have a continuous learning curve than to try to put the industry back together when it is needed.

There are, of course, reasons for opposing these arguments. Even if it is conceded that it would be in the national interest to have the nuclear option, that does not mean it is the responsibility of the Federal Government to ensure it. The economic penalty for not having more nuclear plants would not be crippling (though the total dollar penalty could be quite high) (2,4), and as shown in chapters 3 and 5, unless nuclear plants are built and operated well, they are not the most economic choices. If any more serious accidents occur, forcing long shutdowns and expensive backfits, the economics of nuclear power will be very hard to defend. Thus, it could be more productive economically to concentrate on the development of alternative energy sources.

Therefore, policy options presented here are not intended to prop up a terminally ill industry, but to cure the problems of an industry that is salvageable and which the Nation decided was needed. **In addition, some of the options can be of importance for ensuring that existing reactors operate safely and economically regardless of the** choice about the industry's future.

The next section presents a series of policy goals and options that might be considered by Congress. For some of these, a lead congressional role would be needed. For others, congressional action may be no more than general policy setting and oversight because the main initiative must arise elsewhere.

One of the difficulties facing policy makers is that few if any of these options will be very effective by themselves. Actions need to be taken on a broad front, but the responsibility for these actions is diffuse.

The third section, therefore, groups the options according to three different strategies: first, no change in Government policy as it currently appears; second, remove obstacles in the way of further orders for nuclear plants; third, stimulate more nuclear orders. These strategies correspond to different levels of involvement to which policymakers may want to commit the Government.

The success of these strategies depends in turn on two other factors: the need for nuclear power and how well the industry manages its present reactors. Therefore this section also includes economic and industry management scenarios that are combined into four different futures to help evaluate the strategies.

POLICY GOALS AND OPTIONS

In order for nuclear power to become more acceptable in general, progress must be made in several different areas. Reactors must be more affordable, operations of existing nuclear plants must be improved, concerns over potential accidents must be alleviated, and public acceptance must be improved. This section discusses the specific policy initiatives that would contribute to these goals. The goals and options are listed in table 34. Under each goal the options are listed not by importance, but in order of ease of implementation according to the strategies discussed later.

Goal A: Reduce Capital Costs and Uncertainties

At present, nuclear reactors pose too great a financial risk for most utilities to undertake. Few utilities can support such a great capital cost for the length of time required to build a nuclear plant, even if lifecycle cost projections show that it would be the cheapest power source over the lifetime of a powerplant. Not only are capital cost estimates high, but the actual cost could be much higher if designs continue to change during construction. As discussed in chapters 3, 4, and 5,

Table 34.—Summary of Policy Options

	Strategy[a]	Congressional role
A. Reduce capital costs and uncertainties		
1. Revise the regulatory process for predictable licensing	One	Oversight, legislation
2. Develop a standardized, optimized design	One	Moderate R&D funding (design)
	Two	Major R&D funding (demonstration)
3. Promote the revision of rate regulation	Two	Inquiry; FERC regulation
B. Improve reactor operations and economics		
1. R&D programs to improve economics of operations	Base Case	Minor R&D funding
2. Improve utility management of nuclear operations	One	NRC oversight
3. Resolve occupational exposure liability	Two	Legislation
c. Reduce the risk of accidents that have public safety or utility financial impacts		
1. Improve confidence in safety	Base Case	NRC oversight; minor R&D funding
2. Certify utilities and contractors	Two	Legislation
3. Develop alternative reactors	Two	Major R&D funding
4 Revise institutional management of nuclear operations.	Two	Inquiry, oversight
D. Alleviate public concerns and reduce political risks		
1. Accelerate studies of alternative energy sources	Base Case	Minor R&D funding
2. Address the concerns of the critics	One	Oversight, legislation
3. Control the rate of nuclear construction ., ...	One	Legislation
4. Maintain nonproliferation policies	Two	Oversight of legislation
5. Promote regional planning for electric growth	Two	Legislation

[a]Strategies incorporating these policy options are described later in the chapter: Base Case, Strategy One, and Strategy Two

SOURCE: Office of Technology Assessment.

this situation should improve even without any policy changes, but probably not enough for utilities to be confident in their estimates.

Policy options intended primarily to support this goal are discussed below.

A 1. Revise the Regulatory Process

Regulatory reform has many proponents in the nuclear industry who argue that the licensing process is unpredictable and unnecessarily time-consuming. Some revision may be necessary (if not sufficient) for a resurgence in nuclear plant orders.

Efforts to change licensing will encounter difficulties, however, if they do not account for other points of view. The primary purpose of nuclear regulation is to ensure safety. As discussed in chapters 5 and 6, some utilities and contractors have not performed adequately. In such cases, difficulties with regulation indicate that regulation is working. **In addition, nuclear critics object to any attempt to limit their participation in the regulatory process, and suspect that changes to enhance efficiency would reduce their effectiveness in raising safety** issues. Since critics have considerable influence on public opinion, it will be difficult to achieve enough of a consensus on such revisions. Thus, a complete package of regulatory change should improve the predictability and consistency of licensing nuclear plants while simultaneously ensuring their safety and adequate public participation.

Major proposals for legislative action concern early approval of designs and sites, the hearing process, combined licenses, and backfits. These proposals are evaluated in chapter 6. It is likely that efficiency and predictability could be enhanced by banking designs and sites, and this change could be structured to allow adequate opportunity for public participation. It is less clear that revising the hearing process or combining construction and operating licenses would improve efficiency or allow for adequate public involvement until the technology is more mature. Tighter management within the Nuclear Regulatory Commission (NRC), perhaps with stricter congressional oversight, might make sufficient progress in these areas.

Nuclear utilities are especially sensitive to backfitting, which can be very costly and time-consuming. The controversies surrounding backfits and the proposals for change have been described in chapter 6. There are two related problems. One is that individual backfit orders do not always take into account the impact on other parts of the plant. The second is that estimates of overall gains in safety are not made to weigh against the full cost. The prospect of ever greater costs associated with future backfits to completed plants increases the uncertainty of investment in nuclear power. Decisions on backfits generally have been made implicitly and with little consistency. It is difficult to develop a universally acceptable formula for these tradeoffs since safety is not easily quantifiable, and regulators are reluctant to factor in costs if this could result in any decrease in safety.

Several proposals have been made to revise NRC's backfit rule and procedures. All proposed revisions have recommended changing NRC's definition of a backfit to make it more explicit. **In addition, it is generally suggested that threshold standards for invoking a backfit order be more clearly identified, along with the procedure for implementation.**

These changes could be accomplished through administrative rulemaking, as proposed by NRC, or through legislation, as supported by the nuclear industry and the Department of Energy (DOE). Legislation could make backfit decisions more consistent but would have serious drawbacks if it attempted to be too precise. The techniques for quantifying safety improvements are still somewhat crude, and any cost-benefit analysis would be inherently uncertain and subject to bias. Institutionalizing cost-benefit considerations through legislation also may reduce NRC's flexibility to improve the process later. Such legislation also might be perceived by nuclear critics as restricting safety improvements that might be necessary even if they do not meet the cost-benefit criteria because of all the uncertainties in the technology. A productive Government role in this area might be to develop and refine risk assessment and cost-benefit analysis methodologies so that they can be more confidently applied in backfit decisions.

A2. Develop a Standardized LWR Design, Optimized for Safety, Reliability, and Economy

For a variety of reasons discussed in chapters 4, 5, and 6, the reactor plant designs currently available could be significantly improved. An effort that rethinks the concepts by which reactors have been designed could result in light water reactors (LWRs) that are cheaper, safer, more operable, and perhaps smaller than the present generation. This effort would draw on all that has been learned about the characteristics of good, safe reactors and integrate the best features into a package that would represent the best of technology. The design philosophy would emphasize resiliency and passive safety features as well as affordability and economy. The system would be subjected to intensive analysis from every possible perspective to ensure that, insofar as possible, all contingencies had been covered.

To a degree, the Westinghouse effort on the advanced pressurized water reactor described in chapter 4 meets these objectives. The rationale for a Government role is that a complete reactor and plant design is extremely expensive, and no corporation is likely to be able to finance it unless it sees a major market, which is not now the case. In addition, there are several technical questions such as the unresolved safety issues requiring additional R&D that is best funded by the Federal Government. A Government-initiated nonproprietary design could more easily draw on the work of more than one vendor or architect-engineer as well as a coordinated R&D program, and be available to more producers. Therefore, a national design could have a better chance of being truly optimized. The safety analysis also might be more convincing since it would be done in a more open atmosphere, with direct feedback to the design to improve safety to the maximum extent possible. There is also a growing feeling that current reactors have overshot the ideal size. U.S. vendors are unlikely to be in a position to redesign their new reactors to be smaller.

There are several advantages to a standardized design. The cost would be much more predictable, since most of the regulatory and construction uncertainties could be cleared up before construction started. Costs also could be lowered by incorporating improved construction techniques. It should be cheaper to operate because it would be designed to operate at a higher capacity factor, lower fuel cycle costs and lower operator exposure. Even if the technology were similar to present reactors, this new design package might represent a major improvement in the acceptability of nuclear power.

There are also disadvantages, however. It would be at least as expensive for the Government to sponsor such a design as it would for a corporation—perhaps several hundred million dollars if a demonstration were required. In addition, a Government lead in developing a new design might imply to some groups a dissatisfaction with present designs serious enough that existing reactors should be shut down.

A3. Promote the Revision of Rate Regulation

The process of rate regulation in most States was designed for an era of relatively small capital cost increments and declining costs per kilowatt-hour. High interest rates and high capital costs for new generating capacity have strained the system so seriously that changes may have to be made before utilities resume ordering new central station capacity. The current overcapacity gives utilities a welcome respite, but large construction programs will be needed once again.

Regulatory changes that should be considered here are: 1) rate base treatment of utility assets that takes inflation into account, 2) some construction work in progress (CWIP) to be included in the rate base, and 3) real rates of return on equity appropriate to the actual investment risk. These changes and others are discussed in detail in chapter 3. Their general intent is to even out rate increases and provide greater financial stability for utilities and their customers.

A difficulty for Federal policy in this area is that rate regulation is the prerogative of the States. If Federal action is to be acceptable, it must be taken in a way that makes it in the interest of the States. Federal encouragement of long-range regional planning and regulation (see option D5) may be useful since many States are finding that their regulatory programs are encountering increasing difficulties in forging satisfactory compromises. To some extent, regulation of wholesale power sales by the Federal Energy Regulatory Commission (FERC) influences State regulation. In the summer of 1983, there was extensive congressional debate on legislation restricting FERC allowance of CWIP. Consumer opposition to CWIP has been intense because it allows payment for facilities before they are of any use to the ratepayers. Some States, however, do have partial CWIP allowances.

Goal B: Improve Reactor Operations and Economics

Decisions on the desirability of future reactors will be based not just on capital cost projections (as improved under goal A) but also on the performance of existing reactors. The low reliability experienced at some plants negates their potential economic benefits and raises concerns over safety. Investors, critics, and the public will be opposed to more orders if some plants are noticeably unreliable. Thus, it is in the interests not only of the specific utility involved but of the industry as a whole to improve operations at all plants. Other means for improving the economics of existing reactors could also improve the outlook for nuclear power as a whole.

The specific options toward this goal follow.

B 1. Support R&D Programs to Improve the Economics of Operation

DOE and most of the nuclear steam supply system (NSSS) vendors have modest programs for developing extended burnup for fuel elements. There would be a national benefit from expansion of these programs. Fuel cycle ***costs*** could be reduced slightly, and the volume of spent fuel accumulation would be decreased considerably (perhaps by 40 percent). This latter factor, by itself, could justify a significant Federal effort. Saving 40 percent of the spent fuel would not reduce the spent fuel problem proportionately, but it would ease the total burden considerably in the long term. The objection generally voiced to a Federal program is that private industry could handle it. While this is probably true, a Federal role would expedite matters and improve our international competitive position. A long-term R&D program could provide further benefits.

B2. Improve Utility Management of Nuclear Power Operations

None of the policy options discussed in this chapter will do as much *to* improve the attractiveness of nuclear power for all the parties to the debate as improved utility management. Many utilities were unprepared for the complexities of nuclear power and the dedication required. This situation was perhaps unavoidable, given the overenthusiasm gripping the nuclear supply industry and the Federal nuclear promoters. By now, however, we are in a period of operation, not expansion. Utilities now have the primary responsibility, and **all** utilities responsible for nuclear plants must be adept at carrying it out.

it is important to recognize that much is being done to improve the quality of operations as discussed in chapter 5. The Institute for Nuclear Power Operations (IN PO) was set up for precisely this purpose and has developed a large number of specific programs. The NRC has shifted some of its scrutiny from the plants to the organizations running them. It is not yet clear whether these efforts will be sufficient.

Specific areas for attention are training and organizational structure. Both previously had been left to the discretion of the utility but are now being addressed by both the NRC and IN PO.

Requirements for training show a remarkable variation. Good training programs are expensive, and qualified instructors are in limited supply. It is important to set standards for training and establish reasonable programs for achieving them. INPO is beginning to do this by establishing a training accreditation program. It also may be necessary for NRC to impose these standards to achieve the optimum progress. The NRC probably has the statutory authority to do this, but a congressional directive would expedite NRC actions. Careful observation of the results of INPO's efforts is important to see whether additional NRC action is necessary.

Criteria for organizational structure will be harder to define. One factor that is apparent, however, is that the highest levels of the utility management must be involved with the plants and committed to their good operation. Again, the NRC probably has the authority to command attention at the utility headquarters, and is attempting to do so. Still greater resolve seems to be in order at some utilities, however, and congressional encouragement of NRC to make this a high priority item would help.

Both the NRC and INPO know which utilities are most in need of upgrading their management. All utilities are strongly influenced by the experiences of these few. Strong measures may be required to get the operation of these plants up to minimally acceptable levels. Congressional expresson of the importance of a strong management commitment would be a significant incentive for the NRC and the utilities.

B3. ***Resolve** the Financial Liability for Occupational Exposure*

The weapons testing program has focused attention on compensation for injuries arising from exposure to radiation. New approaches are being developed for compensating test participants and downwind residents, and the industry is concerned that these plans will be applied arbitrarily to commercial nuclear plants (and possibly the medical industry). The proposals under consideration for the weapons tests plaintiffs link radiation exposure to the probability of contracting cancer, and then award compensation based on that probability. With this approach, claimants who receive the most exposure also receive the greatest rewards. Recent legislation in Congress proposes awarding $500,000 to a claimant if there is at least a 50-percent chance that the cancer developed from the radiation exposure. At lower levels of exposure that may only result in a 10- to 20-percent chance of cancer, the claimant could receive $50,000. This proposal is controversial for two reasons. First, the nuclear industry contests the relationship between low radiation doses and cancer since there is insufficient scientific or technical basis to support it. In addition, many claimants who were exposed to low doses would receive compensation for cancers that were not produced by radiation but by other causes. Critics would argue that excluding such cases would deprive a large number of potential victims of just compensation.

Exposure levels during the weapons tests were considerably higher than expected occupational exposures at nuclear reactors. Some workers will, over their lifetimes, nevertheless accumulate a high enough dosage to qualify for awards if the floor is at the 10- to 20-percent level. Hospitals also may find themselves liable for the exposure from X-ray machines and nuclear medicine. Compensation for test victims is an important social issue. It also is important to recognize that it has implications for the nuclear industry that could be serious if the awards are large.

Goal C: Reduce the Risk of Accidents That Have Public Safety or Utility Financial Impacts

Nuclear reactor safety is a function of the design of the plant, the standards by which it is built, and the care with which it is maintained and operated. If any of these are deficient, safety will be compromised, perhaps seriously, and costs may well escalate unexpectedly. Option A2 has discussed how to improve the designs of the next generation of LWRs, but this alone may not be adequate. It would not affect existing plants, and it may not go far enough in assuring safety in future plants. Without a consensus that nuclear reactors now are safe enough, there are unlikely to be any more. Therefore, ways to improve the safety of both present and future reactors are explored under this goal.

The quality of the people involved appears to beat least as important as the design of the plant. Option B2 discusses how to improve utility operation, but again this may be inadequate by itself. Some utilities simply may be unable to improve their performance sufficiently. Others may think they have done so but experience the same difficulties in construction when they order another plant. Two options discussed under this goal can be considered if utility improvement is inadequate. Construction permits and operating licenses could be reserved for utilities and contractors that can demonstrate the commitment to build and operate the plants to the exacting standards required. Second, different institutional arrangements might be considered to replace utility management of reactors, This option also could be effective in stimulating further growth of nuclear power if utilities are reluctant to order more.

Cl. Improve Confidence in the Safety of Existing and Future Reactors

As discussed in the options above, there has been a continual evolution in designs because of frequent discoveries of inadequacies with respect to safety or operation. As our understanding of the technology has improved, formerly unforeseen accident sequences or conditions are recognized. Unquestionably, the technology is maturing, but there is considerable dispute over how much farther it has to or can go.

Part of the problem has been the partitioned nature of the safety analysis both in the industry and the NRC. Each system may be thoroughly scrutinized, but the entire plant is not viewed as a system, and responsibility for analyzing its overall safety appears to be lacking.

No amount of analysis will uncover all potential problems, but an intense analysis of each plant could identify design or operating flaws before they caused problems. These studies are expensive, but a few utilities already are undertaking them in their own interests. The intent is to discover weak points in the design and develop measures to address them, whether by changing plant equipment or modifying operations.

Other efforts to improve safety could focus on improving the analytical techniques. As has been stated above, probabilistic risk assessment is a useful tool that is still imprecise. Development of this technique would be beneficial for both safety and economics. This will involve mainly improving the data base for failure rates and analyzing the human element, as is done in the aircraft industry.

The existence of unresolved safety issues, and the probable introduction of more as new concerns are developed, undermines confidence in safety. Resolving them expeditiously would eliminate some safety concerns, demonstrate a commitment to maximum safety on the part of the NRC, and permit more stable cost projections for future plants. Resolution of some of the issues may call for modifications on existing plants. While the utilities would not welcome such expenditures, the overall reduction of uncertainties and the gains in safety would be useful.

C2. *Certify Utilities and Contractors*

It is readily apparent that some nuclear plants are not being built and operated skillfully enough. As discussed earlier, all plants may be hostage to the weakest because an accident, or even poor performance, reflects on all. If the persuasive approach of option B2 is insufficiently effective in improving nuclear plant management, more drastic steps could be warranted.

For existing reactors, the NRC evidently already has the power to suspend an operating license if a utility is incapable of managing a reactor safely. Few people expect the NRC to do this without the most compelling evidence of incompetence. If higher standards are to be enforced, it probably will only be with congressional legislation. Such improved standards would be in the best interests of the industry even though their implementation could be traumatic. Even if this authority were never invoked, it could be a strong incentive to utilities to improve their performance. The result would be greater confidence in the safety and operability of reactors.

Future reactors present a slightly different picture. Utilities have learned that building reactors is very difficult, and few, if any, would embark on a new construction program unless they were confident they had the ability. Even then, however, other parties of concern may not share that confidence. Certification of utilities as having the necessary ability and commitment to build and operate a reactor to high standards would ensure that many of the expensive mistakes of the past were not repeated. This would reassure many of the critics of nuclear power as well as investors, utility commissions, and the public. It also might be necessary to eliminate from contention contractors who had not demonstrated their capability of meeting the exacting standards required for nuclear construction. Presumably utilities would know better than to select these contractors, but some past experiences have been so poor that making it official would increase confidence.

Even though this option is not likely to prevent any plants from being built, it would be viewed by the industry as another set of regulations to meet in what they consider to be an already overregulated enterprise. The utilities also may resent having a Federal agency judge utility management quality. An independent peer body analogous to that being set up for review of medicare inpatient treatment might meet with better acceptance.

There are no clear criteria as to what constitutes good management concerning construction of a nuclear powerplant. Nevertheless, as part of a strategy to rebuild confidence in the technology, this option clearly bears further examination.

C3. *Develop Alternative Reactors*

DOE has carried on a modest program for R&D on the high temperature gas-cooled reactor (HTGR). Given a higher commitment, the HTGR might develop into a superior reactor. In particular, it has inherent safety features that at least temporarily would shield it from some of the safety concerns of the LWR. Further, if problems develop with the LWR that are too difficult to solve economically, the HTGR probably would be the next available concept in this country. An enlarged R&D program could prove vital in maintaining the nuclear option.

On the negative side, it has to be noted that gas reactors have not been a great success anywhere, and most countries have turned to the U.S. developed LWR technology. Estimates of future costs and reliability are much more conjectural than for the LWR. Many utilities would be reluctant to turn to a less familiar technology that might turn out to be subject to many unforeseen problems. Such uncertainties will only be resolved by a substantial R&D program. To a greater degree than for the standardized LWR discussed above, a thorough demonstration of the entire HTGR concept, including licensability, costs, operability, and acceptability would be required. This would necessitate an increased development program at DOE.

Even if the HTGR is not seen as a replacement for the LWR, there are still several reasons for supporting an R&D program paced to make it available early in the next century. it would use uranium more efficiently than LWRs, has relatively benign environmental impacts, and could be used for industrial process heat. A small, modular form also has been proposed that could have major safety and financial advantages and be particularly well suited to process heat applications.

It is harder to see a role for heavy water reactors (CANDU) in this country. CANDUs are working extremely well in Canada. At least some of that success, however, is due to the managerial environment in which the nuclear industry operates in Canada. Transplanting it to this country could lose these advantages, and would necessitate industry learning and investing in a quite different technology. While the technology can be mastered, a significant research program would be necessary to adapt CANDUs to our regulatory requirements, or vice versa. It is not clear that this effort is warranted compared to other alternatives such as the HTCR or improved LWRs.

The final alternative reactor discussed in chapter 4 is the PIUS, which was conceived largely to meet safety objections to the LWR. While radically different from the LWR in some ways, it still is an LWR. Therefore it has an element of familiarity that the others do not. The concept, or at least some features of it, appear promising, but only a significant research effort will confirm the feasibility of the design since it is still a paper reactor concept, There is great uncertainty over this concept, but if the research program does prove out the expectations of the developers, the reactor could be deployed rapidly. PIUS could be perceived as much safer by the public and critics.

Development of new technology will not by itself solve the problems of the industry. However, it will play a vital role in **an overall** upgrading, whether the end result is an improved LWR or an alternative concept.

C4. *Revise the Institutional Management of Nuclear Power if Necessary*

If a utility has its license revoked as in option C2, or such action seems likely, it might think of turning the plant over to a different operating agent instead of just shutting it down. Utilities already use a large number of consultants and service companies for specific tasks. Operating service companies, discussed in chapter s, could bean extension of these, or they could be other utilities that have established good records and are prepared to extend their expertise to other reactors. The NRC would be satisfied that the plant was being given the management attention required, the utility would have its plant operating again, probably at higher availability than before, and the public would have greater assurance about the commitment to safe operation.

There are potentially serious liabilities to the idea, however. No utility would like to admit that it is incapable of operating its plant safely and would be reluctant to turn to another operating company except under extreme conditions. The contract between the two would have to be carefully worked out to determine who would pay for modifications and maintenance. If a serious accident did occur, plant restoration costs and liability for offsite damages would have to be spelled out. Premature plant closure due to unexpected deterioration could be another problem.

There do not appear to be any legal impediments to the idea that would require legislation. However, Congress might want to encourage the NRC, and perhaps the Justice Department, to undertake further analysis.

Alternative institutional arrangements also could be formed to encourage nuclear orders i n the future. If individual utilities are unable to undertake the risk, consortia of utilities, possibly including vendors and architect-engineering firms etc., might be able to do so. Alternatively, Government-owned power authorities might be the only way to maintain the nuclear option. These concepts are explored briefly in chapter 5.

Goal D: Alleviate Public Concerns and Reduce Political Risks

The issue of public acceptance has permeated this report for good reason. If the long-term trend in public opinion toward increasing opposition (described inch. 8) is not reversed, there will be few, if any, more orders for nuclear plants.

Many of the options discussed above are relevant to this goal. Nuclear energy will not be acceptable so long as there are spectacular examples of out-of-control cost escalations and a continuing series of alarming operating events. A major accident involving offsite loss of life would almost certainly preclude future plants and quite likely close many operating reactors. Therefore, almost any action to improve operations and safety will pay dividends in public acceptance. The options discussed here are intended to reduce the controversy or to confine a role for nuclear power.

01. *Accelerate Studies of Alternative Energy Sources*

One of the major factors affecting public opinion against nuclear power is the feeling that the risks associated with it outweigh the benefits. As long as other energy sources are available that are perceived to be both more economical and acceptable, there is little incentive to favor nuclear energy with its more controversial risks. Therefore, as more information is developed on the resource base, costs and impacts of these alternatives, better decisions can be made on the relative merits of nuclear energy.

The major competitor of nuclear power for new central station plants is coal. Yet coal is arousing concerns (e.g., carbon dioxide and acid rain) that may exceed those of nuclear. Significant research is going on in these areas, and the answers are crucial for nuclear power. The sooner they become available, the easier it will be to make informed decisions.

Some analysts feel that natural gas resources have been greatly underestimated. This cannot be confirmed for many years, but there is an im-

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portant data-gathering role for the Government. If gas remains plentiful and is permitted as a boiler fuel, it will reduce the competitiveness of nuclear energy. From a different perspective, it also might be useful to expand R&Don the solar energy options that appear promising. Some of the euphoria about solar energy has withered under the hard light of costs, but some technologies such as photovoltaics are still candidates. Accelerating these technologies actually could be beneficial to nuclear power. If they ultimately prove to be not widely competitive with nuclear energy, we would know that sooner. If they are reasonably competitive, then the Nation has another option.

None of these proposals is particularly controversial, though some might be expensive. In general, decisions on these options will be made on a basis other than one's attitude toward nuclear power. The outcome, however, could be very important to the future of nuclear power.

D2. *Address the Concerns of the Critics*

Critics of nuclear power have long felt a deep distrust of the industry and the NRC. They feel that their concerns have been ignored or downplayed while the Nation plunged ahead to build more reactors. The mistrust is mutual. The industry feels that nothing would change the mind of the critics.

Bridging this distrust will be difficult at best. For those critics who do not want nuclear power under any conditions and for those in the nuclear industry who refuse any concessions, resolution probably is impossible. However, opposition to nuclear power is not monolithic. Many critics have specific concerns over the technology and its implementation. These critics tend to be technically knowledgeable and respected in the environmental and anti-nuclear communities. Further, some in the industry are aware of these concerns and appear to be willing to engage in a useful discussions. It is with these groups that a bridge might be constructed.

One important step is to resolve the safety concerns that have already been identified, as discussed under option Cl. Further steps may be required to convince critics that every effort was being made to identify previously unrecognized safety concerns and implement solutions at existing reactors.

The most straightforward way of providing this assurance is to involve critics directly in the regulatory process. This might be done through contracts to supply specific information or review material (intervener funding), by including technically knowledgeable critics on the Advisory Panel for Reactor Safeguards, or by creating an office within the NRC that would serve as a liaison to the critics.

Few proposals generate as much controversy as this one. Industry sees it as opening the floodgates to implacable opposition that would make any progress impossible. Utilities see it as presaging a steady stream of new backfit orders and unnecessary regulations. Much of the NRC sees it as an unwarranted infringement on its process. If it is to be implemented, congressional direction will be needed. It may be worth the effort. Nuclear technology is still imperfect, and the sooner problems are discovered, the sooner the technology can be improved. Involving the critics is likely to speed this process. I n addition, improvements in public support is a prerequisite for more orders; public support is unlikely to improve as long as the controversy over safety is so bitter; and this controversy is unlikely to die down until most of the concerns of the critics have been addressed. Given the current impasse there may be little to lose by trying this approach.

D3. Control the Rate of Nuclear Construction

Many of the concerns over nuclear power originated during the late 1960's and early 1970's when projections of very high growth seemed to be on the way to being realized. People became alarmed over the thought of 1,000 reactors or more around the country, many reprocessing plants with spent fuel and plutonium shipments requiring security that disrupts normal transportation and threatens civil liberties, and the ever present possibility of accidents. The industry itself found the rapid expansion more than it could adequately manage.

Lower projections of nuclear growth have reduced some of these concerns. However, a resumption of orders might rekindle the fears of another "too rapid" expansion.

Establishing a controlled growth rate may give assurance that the early. concerns about overexpansion would not recur. As discussed in chapter 8, the 1980 Swedish national referendum limiting the total number of reactors appeared to quell the political controversy.

Controlling the growth rate might realize this improvement in public acceptance without precluding all future orders. The limit could be in the form of capacity that could be granted construction permits in a year, or a sliding scale to allow nuclear construction to remain at a roughly fixed fraction of total new capacity. If utilities' interest in new nuclear orders revives to the extent that the growth rate could be exceeded, the NRC would allocate the permits using criteria of regional need and ability to manage the technology as discussed under A3 above. There is no intrinsic difficulty in the Government allocating limited permits (e.g., airline routes were limited for many years).

This policy option would be controversial, at least at first. The industry would argue that it would constitute unwarranted interference in the marketplace and would distort economic decisions. **In particular, if nuclear reactors turn out to be the most economic form of electric power when managed carefully and** if fully redesigned, controlled growth could result in a misallocation of resources. However, until public acceptance improves noticeably, no utility is going to order any reactors. If controlled growth were instrumental in improving public acceptance to the point that orders resumed, it would be of major assistance to the industry. Furthermore, the burden of proof should be on the industry that it could manage a rapid increase of orders, since many of the present problems came from the last surge. The NRC has the authority to prevent such a surge by insisting on preapproved designs and evidence of utility capability, but a congressionally imposed limit would be more convincing to the public and the critics.

D4. *Maintain a Strict Nonproliferation Stance*

Proliferation has been one of the major concerns of the critics and the public. All known reactors could be used in some fashion to facilitate the production of nuclear weapons. If nuclear power is to regain public trust, this linkage must be minimized.

One step is to keep the U.S. weapons programs and power programs sharply distinct, both technically and institutionally. Separate waste disposal programs could be one step, even though the material is not much different. Consideration also might be given to removing the weapons program from DOE though that would be a complicated decision beyond the scope of this study.

A related suggestion is to consider a ban or extended moratorium on reprocessing. Reprocessing is the focus of much of the opposition to nuclear power. A long-term legislated moratorium, perhaps coupled with the controlled growth in option D3 and the extended burn up of option B1, would eliminate many of the major causes of concerns.

D5. *Promote Regional Planning for Electric Power Capacity*

One of the major reasons for the poor public opinion of nuclear power is the perceived lack of need for it. As discussed in chapter 3, this need is unlikely to be readily apparent before the late 1990's. By then, many utilities may be finding their own capacity fully committed and bulk power purchases less available. Without major changes in the way we generate and use electricity-changes that are highly speculative now —the Nation will need substantial new generating capacity to come online by 2000, and perhaps sooner. Some regions with high growth rates from population shifts and economic changes will experience the need earlier.

Planning for electric growth can make clear what the choices are and what the consequences might be. These plans could help build a consensus on the necessary additional capacity and load management. At the least, plans would provide a format for discussion. in conjunction with the controlled construction rates discussed above, such plans could be quite effective.

National planning is probably too large a scale to be useful. State planning may be too small considering the growing regional nature of power wheeling. Regional planning appears best to capture the commonality of interests, This might be combined with regional rate-setting as mentioned in chapter 3.

insofar as nuclear power is concerned, this proposal might not make any difference. It would not by itself eliminate any barriers to new reactors and might even raise an additional layer of regulation. On the whole, however, it should allow utilities that decide they should build a reactor to make a stronger case for it by showing how it will benefit the customers in the long run.

This policy option would be implemented by setting up regional planning authorities, possibly with ratemaking authority, that are agreed to by the States. It is important that these authorities also have authority to determine power needs. Such responsibility should not go by default to Federal agencies such as the NRC, which are not well equipped to make such determinations. The concept of regional authorities appears promising, but it has not been studied in detail in this project.

MAJOR FEDERAL POLICY STRATEGIES AND THE LIKELIHOOD OF MORE ORDERS FOR NUCLEAR PLANTS

It should be clear from the other chapters in the study that **none of the individual policy options described earlier in the chapter is sufficient by itself to improve significantly the prospects for more nuclear orders.** There are too many different problems that have to be addressed before nuclear power can be again considered a viable energy option for the future.

If several of these policy options are coupled in an overall strategy, however, they may be collectively much more effective. These strategies should include options directed toward each of the four policy goals described earlier in the chapter: reduce construction costs, improve reactor economics, reduce the risks of accidents, and alleviate public concerns. Most of the policy options will be controversial to some extent. For this reason, it is likely to be necessary to take steps that meet the concerns of several different groups at once: utility executives, critics, investors, regulators, and the public. The divergence among the views of these groups should be clear from the rest of the study.

In the face of the controversies surrounding nuclear power and the uncertainties surrounding its future, one obvious Federal course is to make no changes in Federal policy. **If such is the case, future nuclear orders will be heavily influenced by two sets of conditions outside the direct control of the Federal Government: economic conditions and improvement in nuclear industry management. In the section that** follows, the prospects for new nuclear orders in the absence of new Federal policies, the Base Case, are examined for each of four nuclear futures that assume different sets of economic conditions and industry management success.

The two other strategies described here assume various degrees of Federal intervention on several fronts. The first of these, Strategy One, would merely remove obstacles to further nuclear orders. A more active approach, Strategy Two, would go further and attempt to stimulate more nuclear orders. The four futures described under the Base Case also are examined for each strategy to help evaluate how successful the strategies might be under different conditions.

There are also two variations on these strategies that are not analyzed in detail in this study but are worthy of consideration. One of these, a variation on the Base Case, would make several changes in Federal policy to encourage more market competition between nuclear power and other generation (and load management) technologies. The other, a variation on Strategy Two, would consider nuclear power, not so much as an important aspect of U.S. energy policy but as a key element of U.S. industrial and world trade policy.

The Base Case and two strategies are outlined in table 35 with the policy options, discussed in the previous section, listed for each strategy. There is also a brief description of the two variations with a general description of the probable policies under each.

Base Case: No Change in Federal Policies

There are several reasons why policy makers might choose a strategy that avoids any major changes in the current Federal laws and regulations affecting nuclear power. Some policy makers may view nuclear energy as unimportant or undesirable, while others may feel that the Federal Government already has done enough for the industry, making further legislation unwarranted. Still others may not wish to take any action right now. At present there are many uncertainties about future electricity demand, the environmental impacts of coal combustion, and the potential of conservation and renewable resources which will affect the necessity for and attractiveness of nuclear power. Policy makers may prefer to wait 5 or 10 years to see how these uncertainties are resolved before revising current nuclear energy policies. Finally, policy makers may feel that Federal legislation would have little impact on the industry and that economic forces will ultimately determine its fate.

Table 35.–Major Policy Strategies (and the policy options included in each)

Strategy	Policy Options Included
Base Case: No change ***in Federal nuclear policy: Three*** noncontroversial policies that would be useful even in the absence of more orders	
Goals	*Policy Options*
Improve reactor economics	(B1) R&D to improve fuel burnup
Reduce accident risk	(Cl) Improve analysis of reactor safety
Alleviate public concern	(D1) Accelerate studies of alternative energy sources
Variation: Sharpen market competition of nuclear power	
This strategy, not analyzed in detail, would include some or all of steps towards: reduction or removal of Federal subsidies for nuclear and alternatives; marginal cost pricing; deregulation; full costing of external impacts	
Strategy One: Remove obstacles to more nuclear orders: Three policies above plus *five* others	
Goals	*Policy Options*
Reduce capital cost barrier	(Al) Revise regulation
	(A2) Assist funding of standardized optimized LWR design
Improve reactor economics	(B2) Improve utility management
Alleviate public concerns	(D2) Address concerns of critics
	(D3) Control the rate of nuclear construction
Strategy Two: Provide a moderate stimulus to more nuclear orders: *Eight* policies above plus *eight* others	
Goals	*Policy Options*
Reduce capital cost barrier	(A2) Assist funding of a demonstration of new LWR designs
	(A3) Promote the revision of rate regulation
Improve reactor economics	(B3) Solve occupational exposure liability
Reduce accident risk	(C2) Certify utilities and contractors
	(C3) Develop alternative reactors
	(C4) Revise institutional management of nuclear operations
Alleviate public concern	(D4) Maintain nonproliferation policies
	(D5) Promote regional planning for electric growth
Variation: Support the U.S. nuclear industry in future world trade	
This strategy, not analyzed in detail, would support industry and utility R&D and export financing policies aimed at obtaining a major share of the future world market in nuclear and other advanced electrotechnologies.	

SOURCE Office of Technology Assessment.

A "no change" strategy would continue the current Federal policy toward nuclear power. DOE could continue to fund R&D of both the LWR and alternative reactor types at about current levels. Although current NRC efforts to reduce backfit orders and streamline the licensing process would continue, there would be no major legislation and no fundamental changes in present regulatory procedures.

This strategy does assume continuation of two fairly controversial Federal policies. One assumption is that Congress will renew with no major changes the Price-Anderson Act, limiting the liability of plant owners and constructors in the event of an accident (described in ch. 3). Part of the act expires in 1987 and if it were not renewed, it could have a significant impact on the nuclear power industry, although how much and what kind of impact has not been analyzed in this report. A second assumption is that the Nuclear Waste Policy Act of **1982 is implemented success**fully and the feasibility of safe waste disposal will be demonstrated.

The strategy also assumes that three noncontroversial policy options (actually expansions of existing efforts) discussed in the preceding section could be implemented: (B I) R&D for higher burnup and other improvements to reactor economics would be funded; (Cl) Safety concerns would be addressed more vigorously; and

(D1) research into problems and opportunities for alternative sources of electricity generation would be accelerated.

The likely outcome if Federal policy is not changed will depend on two major factors—the success of industry efforts to eliminate current problems, and the economy. Two alternative sets of external economic conditions are considered here. One would result in a relatively high demand for new central station generating plants and the other in low growth. Similarly, the potential range of results of current industry efforts to improve the viability of nuclear energy are represented by two different outcomes: relatively successful and only moderately successful. These outcomes, or scenarios, are summarized in table 36, and will affect the impact of each of the other two strategies described in this report as well as the Base Case results. These scenarios are not predictions or projections of the future, but instead brief sketches of a few of the possible combinations of events that could make nuclear power more or less attractive to utilities over the next 10 years.

Economic Conditions: Two Scenarios

The major economic factors that will affect future demand for nuclear power are the rate of growth in electricity demand, the price and availability of alternative energy and electricity sources, and inflation and interest rates. All of these factors are discussed in greater detail in chapter 3 and summarized only briefly here.

Economic Scenario A: More Favorable to Nuclear Orders.—As shown in table **36,** Economic Scenario A includes a combination of those economic factors that could be expected to make nuclear power more attractive. In this scenario, rapid price increases for oil and gas might accelerate the shift to electricity helping create a moderately high increase in electricity demand

Table 36.—Four Scenarios Affecting the Future of the Nuclear Industry

Economic Scenarios Affecting the Nuclear Industry

Variable	Scenario A: Favor more orders	Scenario B: Hinder more orders
Electricity demand (average annual growth rate 1983-93	3.5%	1 .5 "/0
New capacity needed in 1995 (GW) would have to be ordered in late 1980's[a]	161	0
Additional capacity needed between 1995 and 2000 at same demand growth rate (GW) would have to be ordered by 1992	218	84
Price of alternative fuels:		
Oil and gas	Real price increases *faster* than price of electricity	Real price increases *at same rate* as electricity
Renewable	Real price remains higher than price of electricity	Price becomes competitive with electricity
Inflation rates and interest	Low	High
Environmental impacts	Concerns about acid rain, global CO_2 increase	No constraints on fossil

Industry Improvement Scenarios

Variable	Scenario A: Major improvements	Scenario B: Modest improvements
Average construction time	7 years	12 years
Operation of existing reactors	70% availability	60°/0 availability
Safety risks	Currently operating reactors shown much safer	Little progress on unresolved safety issues
Reportable operating events	Almost none over decade; management improvements obvious	Continue at current rate; much media coverage

[a] See ch. 3 for a complete discussion of assumptions used in capacity projections; GW as used here means GWe.
[b] Possible factors In price increases: limited gas reserves; tight international oil market; increased environmental controls on coal burning.
[c] Steady reserves of oil and gas; continued conservation eases demand.

SOURCE: Office of Technology Assessment.

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(3.5 percent per year). This rate of growth in demand, coupled with a moderate need to replace aging powerplants, is expected to create a need for 161 gigawatts (GW)* of new central station generating capacity by 1995 and an additional 218 GW by 2000. Given the time required to complete new generating plants, utilities would be expected to order this much capacity in the 1983-93 decade.

Under this scenario, increasingly stringent environmental restrictions could make new coal plants very expensive. If this price increase occurred at the same time as the projected growth in electricity demand, utilities would be faced with the need for new capacity while their most important fuel was becoming considerably harder to use. As a result, nuclear power would appear much more attractive to utilities placing powerplant orders. If the inflation rate and prevailing interest rates were relatively low, capital costs of nuclear plants would be more manageable and predictable for utilities. Low inflation and the decreasing construction costs over the next few years will stabilize rates to consumers, very likely lessening hostility to utilities. In addition, the benefits of nuclear power would grow in the eyes of the public as electricity demand increases.

Economic Scenario B: Less Favorable to Nuclear Orders. —If the economy follows this path, nuclear power remains relatively less attractive. In this scenario, moderate price increases of gas and oil slow the shift to electricity. In addition, renewable energy sources become more competitive with central station electricity. As a result, there is only slow growth (1.5 percent) in average annual electricity demand, and no new generating capacity must be completed in the decade. However, even at this slow rate of growth, if moderate numbers of existing plants are retired, about 84 GW of new generating capacity would be needed by the year 2000, and this capacity would have to be ordered in the 1983-93 time period. With relatively small increases in the price of coal, and high interest rates driving up the capital costs of nuclear plants, utilities would be more likely to invest in coal-fired plants.

*One gigawatt equals 1,000 MW (1,000,000 kW) or slightly less than the typical large nuclear powerplant of 1,100 to 1,300 MW.

in Economic Scenario B, rapid inflation over the next few years would cause continued price increases and continued high interest rates during completion of the 30 nuclear plants now under construction. Utilities would be forced to request large rate increases from utility commissions as the plants are finished. These rate increases, combined with the slow growth in electricity demand, would cause consumer opposition and increased public skepticism about nuclear power. All of the assumptions included in Economic Scenario B would be expected to make new nuclear plants less attractive to utilities.

Management Improvement Conditions: Two Scenarios

Industry and utility success or failure to make substantial improvements in the management of the nuclear enterprise will be reflected in several indicators: leadtime to build nuclear plants; average plant availability; progress on unresolved safety issues; and frequency of precursor events. These subjects were discussed in chapters 4 and 5.

Management Scenario A: Major Improvement.—In Management Scenario A, the nuclear industry would be very successful at overcoming some of its current difficulties without government assistance. Utilities currently operating reactors would overcome operating and safety problems, creating a steady improvement in reliability of operating reactors. Improved operation of existing plants and projections of reduced construction costs would make nuclear power more economically attractive to investors and public utility commissions as well as to consumers.

Management Scenario A assumes that operating plants and those completed over the next decade would be shown to be much safer than presently assumed because of improved operations and better understanding of the technology. Improved analysis and information (e.g., the ongoing research into "source terms") could demonstrate other safety characteristics (as discussed in ch. 4).

Two consequences would follow from these safety improvements. First, the management changes would greatly reduce major events, such as the failure of the automatic shutdown system at the Salem, N. J., reactor, which are viewed by the public as precursors to a major accident. Second, the new information on the small amount of radioactivity released in the event of an accident would temper the reaction to the few operating events that did occur over the decade. **These safety gains should be helpful in reducing public opposition to the technology and further increasing investor confidence.**

In addition to the improvement in utility management of operating reactors, the nuclear supply industry would be offering improved standardized **LWR designs such as the APWR currently being developed by Westinghouse and Japan. Under current regulatory policy, the NRC** could give licensing approval for a complete design, and, if a plant were built exactly to the design, there would be few regulatory changes during construction. **Thus, the regulatory environment would become somewhat more predictable without any major Federal legislation.**

Management Scenario B: Minor Improvements.—In Management Scenario B, some of the **weaker utilities would fail to improve their** performance despite the efforts of INPO and the NRC. Average availability for operating plants would be only about 60 percent, and there would be little progress in solving unresolved safety issues. poor management of operations would continue to cause precursors to serious accidents, and the media would continue to give extensive coverage to these near-accidents and major construction problems. One operating event might be so significant that a plant would have to be shut down for several months to a year for repairs. Without an adequate insurance pool, this would cause a major rate hike to cover purchased power. The long construction periods, continuing operating problems, and rate hikes due to outages would increase investors' and consumers' skepticism of the technology.

without Government intervention, this scenario could be expected to have very negative consequences for the industry regardless of external economic events.

Four Nuclear Futures Under the Base Case: No Policy Change

The two sets of economic conditions described above combine with the two management scenarios to form four futures that illustrate the range of possibilities for more nuclear orders. Future One is a combination of favorable economic conditions (Scenario A) and major improvements in management (Scenario A). Future Four combines the least favorable scenarios. Futures Two and Three are intermediate. The discussion that follows describes the factors under each future that would affect decisions on new nuclear plants. The four futures and their likely outcomes are summarized in table 37.

Future One.—Under the assumptions of Future One, there is a clear need for more generating capacity, the cost of other fuels is rising rapidly, operating plants are performing well, and industry offers improved, standardized designs. As discussed in chapter 8, public acceptance of nuclear

Table 37.—Four Combinations of Economic and Management Scenarios Under the Base Case

	Economic Scenario A: More favorable **Fairly rapid growth in demand; utility alternatives costly; low interest/ inflation.**	**Economic Scenario B: Less favorable** Slow growth in demand; alternative energy available; high interest/inflation
Management Scenario A: Major improvement 7-year construction time; 70% per availability; safer reactors; few precursor events	**Future One** Some further orders possible, especial. Iy if standardized preapproved designs are available.	[redacted]
Management Scenario B: Minor improvement 12-year construction time; 60°/0 availability; little progress on safety; continued precursors.	Future Three A **few well-managed utilities may order plants over the next decade.**	**Future Four** More orders very unlikely before 2000; a few possible after 2000.

SOURCE: Office of Technology Assessment.

technology is influenced by perceived benefits as well as by perceived risks. Therefore, the increased electricity demand in Economic Scenario A, combined with the safety improvements envisioned in Management Scenario A could be expected to increase support for nuclear energy. Utilities would be more confident that plants could be completed without unreasonable delays due to changing regulations or intervention.

Under these circumstances, and if the 7-year construction period for some recent plants appears achievable for new plants as well, **some utilities might be willing to order new nuclear plants even without changes in Federal policy. However, most utilities would still be deterred by uncertainties and risks, especially regulatory delays and costs.**

Those utilities with a need for new capacity might choose to share these risks by forming a consortium. This consortium could order several plants based on the best current design and share the necessary startup costs with component manufacturers. Under current regulatoy procedures, the NRC could grant simultaneous construction permits for three or four new plants. The SNUPPS consortium in the early 1970's is a prototype of such an effort (see ch. 5). If the plants were built in strict accordance with the complete design, there would be only minimal requirements for changes during construction.

A problem-free licensing and construction process would demonstrate to other utilities the benefits of standardization and show that at least some utilities were committed to the technology. **Given the need for additional power and the consortium's expected success, nuclear orders might "snowball" without any major Federal action.**

Future Two.–The safety and management improvements, reduced construction times, and expected increased public acceptance under Management Scenario A would make nuclear power a more attractive option. However, the assumed slow growth in electricity demand in Economic Scenario B would make utility investment in any type of new powerplant unattractive throughout most of the decade.

As discussed earlier, Economic Scenario B envisions that 84 GW of new electric-generating capacity would have to be ordered only at the end of the 1983-93 decade. By then, the absence of orders and slowdown in construction would have eliminated many suppliers of nuclear plant components and services, increasing the cost of a new nuclear plant. This cost increase, combined with high inflation and interest rates, might offset the savings from reduced construction times envisioned in Management Scenario A, further discouraging nuclear orders. Given the overall risks and uncertainties, it is unlikely that a utility would order a nuclear unit unless its projected costs were much lower than a similar coal plant. This is unlikely, however, because poor business prospects would keep nuclear companies from investing heavily in the design and analysis needed to reduce costs.

At most, only one or two utilities could be expected to order a nuclear plant under Future Two, given no major change in Federal policy. Any orders that did occur probably would come from a very experienced nuclear utility and most likely would be in the form of initiating or completing construction at a currently inactive plant site. **However, it is more likely that there would be no orders at all over the next decade under these circumstances.** Given some utilities' current problems with nuclear energy, no utility would want to be the only company venturing into a new nuclear effort.

In the 1990's, with few or no new orders, the U.S. nuclear industry would lose most of its expertise in plant design and construction, and suppliers of key components would drop out. De**spite these problems, some utilities could be interested in ordering reactors toward the end of the century, especially if demand growth starts to increase.** By then, the utilities would probably find a Japanese, French, or West German design preferable to outdated U.S. plant designs. If U.S. companies wanted to offer the most current reactor designs, they might have to license them from foreign companies, perhaps the very ones they had licensed to build LWRs in the first place. In either case, as discussed in chapter 7, U.S. companies probably would still have the resources to tailor the designs to American needs and to build the plants.

Future Three.-The poor management conditions of Management Scenario B, under a policy of no change in Federal policies, would create serious tensions between the need for nuclear powerplants and continued opposition (by investors, critics, and the public) to their high costs and risk. As discussed previously, this scenario envisions constraints on fossil fuel combustion, encouraging utilities to consider purchasing nuclear plants, Those utilities with successful experience in building and operating nuclear plants would not be deterred directly by the poor experiences of others. Indirectly, however, all utilities are "tarred by the same brush" aimed at the weaker utilities by the NRC actions, the public, investors, and others. Thus, the lack of major industry improvements envisioned in Management Scenario B would cause present uncertainties to continue.

Moderate interest and inflation rates assumed under economically favorable Economic Scenario A might help to offset the cost escalation resulting from the lengthy average construction period expected in Management Scenario B. This would moderate the "rate shock" as new plants came on line, reducing consumer opposition slightly. Public perception of increased electricity demand could be expected to offset concerns about safety risks slightly, perhaps returning public opinion to a 50-50 split on the technology.

The **net effect of favorable economic conditions combined with little change in the state of the industry and no major Federal policy change would be that, at most, only a few utilities would order new nuclear plants over the next decade.** Despite the constraints on fossil fuel combustion, most new plants would be coal-fired, with environmental controls to meet current regulations. With only a few new orders, subsequent events would follow the path outlined for Future Two. In essence, the U.S. nuclear industry would slowly decline, and any new nuclear plants ordered after 1995 might be of foreign design.

Future Four.–With the combination of both Management Scenario B (Minor Improvement) and Economic Scenario B, there is little prospect for any nuclear orders with no change in Federal policies. Continued management and safety problems at plants currently operating and under construction, slow growth in electricity demand, and increasing competitiveness of other fuels, create a climate in which no utility could be expected to order a new nuclear plant. In the inflationary environment expected under Economic Scenario B, utilities would be very reluctant to invest in capital-intensive plants of any type. Instead, utilities could be expected to match supply and demand through load management, efficiency improvements to existing coal plants, and cogeneration, contributing to the slow overall rate (1.5 **percent)** of growth in electricity demand.

Near the end of the 1983-93 decade, some utility executives might order relatively inexpensive combustion turbines to supply the 84 GW of new capacity needed by 2000. Although Economic Scenario B expects moderate gas prices, an increased reliance on gas and oil for electricity generation might drive up prices, resulting in much higher electricity prices. Despite high interest and inflation rates, a few utilities might order coal- fired plants in the early 1990's. The electricity from these plants would be rather expensive because of the high capital costs, further**ing** dampening growth.

Most designers and equipment suppliers would leave the business, leaving a much smaller U.S. industry. Because public opposition would be high under this combination of scenarios, utilities would be unlikely to order new plants from abroad, and no new nuclear plants would be built in the United States before 2000.

Even in Future Four, however, **there is a possibility that new nuclear units could be built after 2000.** As discussed in chapter 7, the U.S. nuclear industry is very resilient. By maintaining its expertise with fuel service and waste disposal business, the industry still should be capable of building a reactor (probably based on foreign designs and components) if events after *2000* created a renewed interest in nuclear power.

Base Case Variation: Let Nuclear Power Compete in a Free Market

Electric utility investment decisions are shaped as much by regulatory practices as by the market. This section notes some of the problems in investment decisionmaking which may have an impact on orders for nuclear powerplants and proposals intended to bring the discipline of the free market to generating capacity investments.

The first problem is that the regulated retail price of electricity is based on the average cost of all generating sources, but any incremental demand must be met with new generating capacity. Under some conditions new generating capacity costs considerably more than average. This is especially true if existing capacity includes a high proportion of largely depreciated coal-burning units or older nuclear units. Under these circumstances there is a mismatch between the price signals consumers receive, and the decisions utilities have to make.

A second problem is that regulation combined with inflation can discourage investment in capital-intensive projects such as nuclear powerplants even if they are the least expensive options in the long term. in times of inflation, regulators tend to delay increases in allowed return to equity investment, and the actual return lags behind the allowed return. Furthermore, inflation combined with book value accounting tends to load the capital costs of a project into the early years where it will be difficult to accommodate them in the rate base. Some of these problems have also been tackled in proposals for rate return **(e.g., regional rate** regulation, CWIP, trended original cost, etc.) described elsewhere in this chapter.

The most comprehensive proposals for changes fall under the general heading of the "deregulation of electric utilities." Such proposals range from selective deregulation of sales of wholesale power among utilities to a massive restructuring of the electric utility industry into unregulated generation and transmission (G&T) companies and regulated distribution companies. The theoretical advantages and disadvantages of various kinds of deregulation and the many practical problems were analyzed in detail in a recent comprehensive report (1 O).

Overall, the analysis concluded that the theoretical benefits of more comprehensive forms of deregulation are sufficiently uncertain, and the practical problems sufficiently difficult, that any move towards deregulation should proceed slowly and cautiously. The report also identified some limited steps toward deregulation that would encourage the kind of competition among generating technologies that is most likely to lead to short- and long-term gains in efficiency. These steps include: 1) more Federal encouragement of power pooling and coordination, 2) rate structures (including experimental deregulation) for wholesale power sales regulated by FERC that encourage efficiency of operations, 3) encouragement of utilities to form generating and transmission companies within holding company structures, 4) mergers between small utilities partly to facilitate the contractual arrangements within power pools, and 5) encouragement of retail rate structures that reflect the incremental cost of increased electricity demand.

Step 5 above includes "marginal cost pricing," another category of proposed change. The rate structure could be adjusted so that customers pay more for electricity at times of day or in seasons when it costs more to provide. Alternatively, customers could be charged more for each incremental block of electricity they purchase. A move toward marginal cost pricing may be useful to encourage load management, especially in regions where capacity utilization is poor. It is less obvious how to use marginal cost pricing to improve the accuracy of the price signals with respect to nuclear power. Nuclear power is base load electricity generation and would be affected only slightly by seasonal or time-of-day pricing. Further, rate regulation would have to be modified to account accurately for the true marginal cost of nuclear generated electricity. Because of the peculiarities of current rate regulation described in chapter 3 (and addressed in policy option A3), the cost of the first year of nuclear power is more than twice as much as the 20 or 30 year levelized cost which is the true marginal cost.

Another problem with the current system is that some of the costs of different sources of electricity are not fully reflected in the private cost of such sources. Nuclear power receives some direct or indirect Federal assistance of several kinds: 1) Federal limits on public liability following a nuclear accident (the Price-Anderson Act), 2) Federal subsidies for uranium enrichment, and 3) the Federal cost of nuclear safety regulation and nuclear R&D. Coal-fired electricity also receives Federal assistance from: 1) black lung payments (currently about $1 billion/year); 2) Federal coal mine regulation; and 3) no charge for air pollution within regulatory limits.

investment comparisons for nuclear power and competing generating technologies would be more accurate if these subsidies were eliminated. This study has not analyzed the consequences of reducing Government support, such as R&D or the effects of eliminating the Price-Anderson liability limitations. It does seem clear, however, that such acts would be viewed by both the industry and the public as signaling a lessening of the Government's commitment to nuclear power. At this point, the industry can ill afford such signals. Therefore, it should be recognized that taking these initiatives, whatever their overall merits, may well be tantamount to ending the nuclear option, at least for the foreseeable future.

Strategy One: Remove Obstacles to More Nuclear Orders

The intent of this strategy (see table 35) for a list of policy options) is to establish an environment in which utilities would be more likely to consider nuclear reactors if demand does pick up over this decade and, at the same time, to establish policies that would win the support of nuclear critics and the public.

The policy options included here work together to achieve these ends. Two of the options, (Al) revise regulation and (A2) develop standardized optimized LWR designs, are closely linked. These options would eliminate some of the major concerns utilities have over nuclear. It is more difficult to predict how to gain the necessary public support. Strategy One includes three policy options designed to reduce the controversy over nuclear power and the concerns of the public: (62) improve utility management of nuclear plants, (D2) address the concerns of the critics, and (D3) establish limits on future nuclear construction within the context of a balanced energy program.

Of these policy options, the easiest to implement is the involvement of the NRC **in upgrading utility management. Such a program already exists. The challenge is to make it motivate utilities to excellent performance (as is discussed in ch. 5) rather than merely to avoid getting** in trouble with the NRC. This is probably only possible if the NRC program is developed in close cooperation with IN PO. There are several possible ways discussed earlier to involve interveners more closely in monitoring and improving nuclear plant safety. This policy option is likely, however, to stimulate substantial opposition from utilities unless it is clear that it is closely coupled with licensing and backfit reform.

The effect of Strategy One on utilities' perceptions of costs and schedules would be mixed. Licensing and backfit reforms would help assure utilities that they could build the plant as designed once a construction permit were approved. However, opening the process more to the critics introduces another element of uncertainty, especially for the first few orders. Furthermore, these proposed reforms would not necessarily dramatically reduce capital costs, so electricity from average cost nuclear plants still could be perceived as more costly than electricity from average cost coal plants in most U.S. regions (see ch. 3).

The impact of Strategy One on orders for new nuclear plants also would vary sharply for each of the four nuclear futures described above for the Base Case. As can be seen in table 38, the impact of this strategy under each of the four futures does not differ greatly from the impact of the Base Case. **In light of the considerable difficulty that** would be involved in implementing the five policy options, this finding suggests that Strategy One maybe only marginally effective.

Future One.—Under these conditions that are relatively favorable for more nuclear orders, Strat-

Table 38.-Alternative Nuclear Futures Under Strategy One: Remove Obstacles to More Nuclear Orders

	Economic Scenario A: More favorable	Economic Scenario B: Leas favorable
Management Scenario A: Major improvement	**Future One** A few **orders likely if utilities are willing to be the first; a consortium and/or turnkey contracts could initiate ordering.**	[redacted]
Management Scenario B: Minor improvement	**Future Three** **Orders unlikely because of low public acceptance and continued regulatory difficulties, perhaps enhanced by the greater participation by the critics.**	**Future Four** Orders unlikely even after 2000.

SOURCE: Office of Technology Assessment.

egy One would increase the likelihood relative to the Base Case. Utilities would have greater confidence that a new reactor could be built close to the projected cost and schedule. Most major design questions would have been worked out before construction had started. The NRC essentially would have approved the design and apparently would be ready to move an application through expeditiously. Critics would have been given ample opportunity to critique the design. Controversy over nuclear power would be noticeably lower because the last of the present reactors under construction would be complete without a continuation of the cost overruns they are now experiencing, and operating reactors would show considerably improved performance,

Under such circumstances, vendors might be willing to encourage the first orders by offering a fixed price "turnkey" contract. The first few plants might not be much less expensive than present plants under construction, but simplified engineering and cumulative construction experience would be expected to cut the cost of a typical plant 20 to 30 percent from current levels (see chs. 3 and 5). Utilities might hesitate to order the first few plants largely because of doubts that cost and regulatory problems really had been solved. Sharing the risk with the vendors would do much to alleviate these concerns. If the experiences of the first few orders were favorable, further orders could be expected in line with demand growth.

Intervener involvement in the licensing process for standard designs combined with the effects of good management on plant operations should reassure nuclear critics and reduce the reasons for opposition to nuclear power in licensing procedures and electricity rate hearings. The strong need for more powerplants coupled with the relatively high prices and environmental problems of coal in Economic Scenario A increase the relative advantage of nuclear and also reduce opposition at State regulatory hearings.

Future Two.– If economic and industry management conditions are less favorable than they are in Future One, the policies of Strategy One will not succeed in stimulating very many orders. In Future Two, industry management is assumed to improve substantially but electricity demand grows slowly and inflation and interest rates are high, discouraging capital expenditures. Because of fewer precursor incidents, public acceptance grows, but there is little obvious need for nuclear powerplants.

With only 84 GW to be constructed by 2000, there would be little pressure to diversify into nuclear. With few prospective orders, vendors and architect-engineers would be unlikely to take the risk of offering turnkey projects. A few utilities, seeking to preserve the option, might make a point of at least considering a few nuclear plants. The new standardized designs, especialy if smaller than current designs, and streamlined licensing could make reactors competitive with coal. **Under Future Two, Strategy One has a somewhat better chance than the Base Case of leading to a few more orders by the end of the century.**

Future Three. -Under these conditions, Strategy One actually could reduce the prospects for new nuclear orders from what they are under the Base Case. With continued poor plant operating performance and continued precursor events, nuclear critics will not be satisfied that adequate progress is being made. With intervenors more closely involved in safety regulation, the lack of progress on resolving safety concerns could increase the time devoted to particular safety issues. Even with high growth, the utilities are likely to regard more nuclear orders as too risky, not only from technical problems raised by the NRC and the critics, but also from the financial impact of public opposition on rate hearings and investor decisions.

Future Four.– Finally, the policy options of Strategy One could diminish still further the prospects for nuclear orders under the dismal conditions of Future Four which combines both adverse economic conditions and little industry improvement. The combination of intervener involvement with poor industry improvement and little apparant need for nuclear power could create conditions of public opposition that would make orders unlikely even after 2000.

Strategy Two: Provide Moderate Stimulation to More Orders

Strategy Two builds on Strategy One. It assumes that efforts to remove obstacles to more nuclear orders would be inadequate, largely because utilities still would be unconvinced that the problems were resolved. As in Strategy One, policy measures to reduce capital and operating cost of nuclear plants are combined with policy measures to make nuclear power more acceptable to nuclear critics and the public.

The first policy option is a demonstration of the reactor(s) developed under A2 as discussed in Strategy One. The main purposes would be to show that the reactor could be built according to design and that the licensing process could handle it as expected. It could be expected that private industry would fund most of this project since technological feasibility is not i n question, but significant Federal participation could be required.

A second step is (A3) Stimulate improved rate regulation treatment of capital-intensive projects. No Federal budget is required for this policy option but sensitive Federal leadership is needed since rate regulation traditionally has been left to the states.

Strategy Two adds a politically controversial step to improve operating economics with (64) Reduce uncertainty about occupational exposure liability. Clarifying occupational exposure conditions and ranges of possible payments to exposed workers with health problems might add expense to the operation of nuclear plants but would reduce the uncertainty which accompanies an unspecified liability (which could be the subject of private lawsuits, such as is now happening with asbestos exposure liability).

Strategy Two includes three additional options to reduce the risk of a reactor accident. (C2) would

Table 39.—Alternative Nuclear Futures Under Strategy Two: Provide a Moderate Stimulus to More Nuclear Orders

	Economic Scenario A: More favorable	Economic Scenario B: Less favorable
Management Scenario A: Major improvement	Future One Some plants ordered by about 1990; more by the end of the century.	[redacted]
Management Scenario B: Minor improvement	Future Three New orders likely only if Government options to improve management have a big impact on utilities and public opinion, resulting in Future One; new reactor types would be useful.	Future Four Government actions to improve management and R&D funding of new reactor types should improve prospects for more orders after 2000.

SOURCE: Office of Technology,

require the NRC to restrict construction licenses for nuclear plants to qualified utilities and construction contractors. Substantial Federal funding, up to several billion dollars over 10 years or more, would be required for a second step: (C3) Fund a major R&D program on alternative reactor types. If this option is pursued at a high level, the demonstration LWR probably would be deleted. For a third option, (C4) Revise institutional management of utilities, there could be controversial changes in Federal and State utility regulation, antitrust law and other long-standing institutional guidelines. These steps should ensure the availability of reactors and operators in which the public could have great confience.

Substantial changes in public acceptance of nuclear power are needed to accumulate the political capital for either large Federal budget expenditures or for Federal efforts to change utility rate regulation or utility institutional management. Two options included in Strategy Two go further than the steps in Strategy One to alleviate the public's concerns about nuclear power and sharpen the basis for judgment about the long-term need for nuclear power. (D4) reduces concerns over the linkage between nuclear power and nuclear weapons by such steps as banning reprocessing. (D5) encourages or requires the use of regional planning and perhaps rate regulation, to improve the consensus on the long-term need for capital intensive technologies such as nuclear power.

Future One.–Strategy Two would have a big impact on conditions such as those in Future One which hypothesizes rapid demand growth and successful industry improvement, but also utility reluctance to place the first nuclear order after a hiatus in orders and substantial public controversy.

Perhaps the best vantage point from which to appreciate the possible need for Strategy Two is from a look forward to 1993 under the assumptions of Future One if there have been no nuclear orders even though Strategy One has been implemented. It is likely that the main obstacle to any nuclear orders would be utility uncertainty that all the problems had actually been resolved, despite the steps in Strategy One. By 1993, more coal fired capacity would have been ordered over the previous 10 years than existed in 1983, but concerns over the environmental impacts would be rising sharply. Stringent new emission regulations would appear probable, but would be very expensive. The costs of other fuels also would be rising rapidly. Other industrial countries, especially France, Japan, West Germany, Great Britain, and Canada would have maintained their nuclear programs, and their cheaper electricity could give them a competitive edge in certain areas of international trade. Utilities would have raised their standards of nuclear operation such that mishaps rarely would occur and reliability would be high. Americans in 1993 might well wonder what went wrong with our national decision making,

What would Strategy Two have accomplished in the same period? How would utility uncertainty have been reduced? Under the conditions of Strategy Two, utilities would have a clear demonstration of Federal government commitment to resolving the problems with nuclear power and good reason to expect that nuclear plants definitely would be cheaper than coal plants in most regions of the country.

By 1990, the standardized design would be sufficiently well proven that interveners, NRC and nuclear designers would be satisfied that it was very resilient to any accident sequences anyone suggests. It would be clear to all that construction of the first standardized plant was proceeding smoothly on schedule and within budget. The NRC would offer a construction permit based on its previous review of the existing design, with only site specific characteristics to be approved. The financial burden on utilities would be lessened because of reduced construction cost and changes in rate regulation, and, perhaps, because smaller reactors would be available. Alternatively, the HTGR or one of the other reactors could be in an advanced stage of development.

Given the strong demand, low interest rates and relative unattractiveness of other fuels in Economic Scenario A, there is little doubt that utilities would order nuclear plants if they were convinced costs would come down and public acceptance would be sufficient to avoid serious economic risk to the plants. Nuclear critics and the public would have been reassured by a decde of steadily improving nuclear plant performnce, the closer involvement of interveners in licensing, a nationally agreed limit on future nuclear construction and the several other measres of Strategies One and Two. In addition, the obvious need for generating capacity would lead to considerably greater public acceptance for more nuclear plants by 1993.

Under these conditions, some plants would be ordered in the early nineties and probably a larger number in the late nineties. Strategy Two thus makes probable what is only a possibility under the same favorable conditions of Strategy One. While it is difficult to be precise, this policy package could lead to more nuclear orders even under conditions somewhat less stimulating than in Economic Scenario A. A growth rate in electricity demand averaging 2.5 percent might have the same probability of initiating nuclear orders as 3.5 percent did under Strategy One.

Future Two.– If utility management were improved but economic conditions were much less favorable to nuclear orders, as in Future Two, much of the effort going into standardized design could be wasted. When the time came for new orders n-ear or past 2000, a foreign design, an alternative reactor type, or possibly photovoltaics might appear more appropriate. Thus, this effort might be dropped if demand growth stays low. An effective program to develop alternative reactor technology could prove to be the crucial reassurance to utilities contemplating new orders after 2000. Utilities that might be unwilling to be the first or second to order a new reactor type might be willing to be the third or fourth.

The other steps of Strategy Two (coupled with two decades of good management) would be useful in changing the climate of public opinion to be more receptive to nuclear power in the long term. With demand growth of only 1.5 percent annually, such changes are likely to be important even when there has been good utility management.

Future Three. -Strategy Two might not be feasible if utility management of nuclear reactors improved very little, as is assumed under Future Three and Future Four. The consensus that would be required for the large Federal budget expenditures and the changes in Federal-State relations on utility rate regulation would not emerge.

For Future Three, with favorable economic conditions for nuclear orders, Strategy Two might be implemented in stages beginning with options to restrict construction licenses to qualified utilities (C2)—and perhaps revoke operating licenses as appropriate,—and changes in utility institutional structures (C4), allowing utility service companies to take over poorly run plants. In effect, these actions would change the situation to that of Future One.

If these actions are insufficiently successful, future orders probably would be contingent on the development of inherently safe reactors which, by allaying many safety concerns, would restore some degree of public acceptance.

Future Four.–Strategy Two would be very hard to justify for Future Four with both little industry improvement and unfavorable economic conditions. The options to improve utility management, however, would help improve public acceptance for after 2000, which is the earliest nuclear orders might be placed. It also is possible that a modest level of investment in new reactor types could lead to a more ambitious effort in the nineties when public acceptance would be improved as a result of NRC efforts to improve utility management.

Strategy Two is clearly a high-risk, high-gain strategy. Under the circumstances of Future One it could assure the future of the U.S. nuclear industry, although it might not even be necessary to stimulate nuclear orders if the industry itself takes sufficient steps to improve the technology and if demand for electricity grows rapidly. Under other circumstances, Federal efforts and funds could produce little of value (Future Two) or be impossible to carry out (Futures Three and Four).

Strategy Two Variation: Support the U.S. Nuclear Industry in Future World Trade

In this variation of Strategy Two, the Federal Government also would play an activist role in supporting the U.S. nuclear industry. The rationale for this variation would come, however, from a completely different source. Rather than regard nuclear power as an element of U.S. energy policy, the strategy would treat the nuclear industry, and related electrotechnologies, as key elements of an emerging U.S. industrial policy.

Several assumptions about the current nature of world competition in nuclear technologies underlie this approach. One is that the advanced reactor designs now underway with joint U. S.-Japanese teams will establish a new standard LWR for the 1990's that will make more modest improvements obsolete. These designs—probably to be licensed jointly by Japanese and U.S. vendors—may well account for any nuclear orders in the 1990's. These designs should give both the United States and Japan a very strong position in world nuclear trade.

The second assumption underlying this approach is that there will beat least one more generation of non breeder reactors after these advanced LWRs become available. The slowdown in plant construction, potential for extended burnup and new uranium discoveries all would make it likely that nonbreeder reactors will be competitive for several more decades. The standardized LWR discussed in option A2 or one of the advanced alternative reactors in C3 could be the choice.

The question is: should the U.S. Government encourage a strategy of R&D that leads to the next stages of reactor development beyond the joint Japanese-U.S. vendor projects? Several elements of a general industrial policy could be applied to nuclear power: 1) support for R&D into product development, 2) relaxation of antitrust prohibitions on cooperation among businesses during the product development stage of R&D, and 3) financing assistance in export promotion through the Export-Import Bank (7,8).

Such a strategy might be especially productive because of the historically low spending on R&D by the electric utility industry. The $250 million budget of the Electric Power Research Institute (EPRI) represents only about 0.25 percent of electric utility sales each year. General manufacturing industries spend about 2 to 3 percent of sales on R&D and high technology industries may spend up to 10 to 15 percent.

A major increase in R&D for the electric utility industry could be allocated among:

- elect rotechnologies for industry such as plasma reduction of iron or microwave heating;
- commercialization of photovoltaics and the solid-state control technology needed to integrate them in the grid; and
- a more advanced nuclear reactor for beyond *2000.*

It seems likely that a balance among support for different advanced generating technologies, including photovoltaics as well as advanced nuclear reactors, will be necessary to get widespread support. Utilities also are likely to favor diverse R&D because of the financial risk inherent in relying on single technologies.

One approach to obtaining funding for such an R&D effort is to make the treatment of R&D in utility rate regulation more attractive. The telephone industry traditionally has included R&D in the rate base in most States.

Federal action in support of this policy strategy would have several elements:

1. Selection of these technologies as a significant element of U.S. long-term industrial policy, and expansion of these R&D programs.
2. Legislation providing incentives or requiring States to allow R&D expenditures in the cost-of-service.
3. Increased Federal funding for some joint EPRI-DOE projects,
4. Elimination of antitrust penalties for vendor cooperation on an advanced reactor design.
5. Consideration of long-term loans such as the Japanese government made available to the semiconductor industry.
6. Attractive financing to foreign customers for nuclear technology exports-through the Export-import Bank.

Implementation of such a strategy would give the U.S. a headstart in world competition just when U.S. orders could be expected to pick up because of load growth and replacement of ex-

isting plants. It could result in a healthy nuclear industry with brighter export prospects, and more attractive options of both supply and demand for the electric utility industry. Electricity consuming industries would also benefit, some quite significantly.

There are some obvious difficulties with this strategy. Given the Federal system, it may be very difficult to get State support for more favorable treatment of utility R&D expenditures. Although some R&D will be carried out by manufacturers, a comprehensive strategy will not work unless a major part of the impetus comes from the electric utilities. Utilities should derive a major part of the benefit, aside from being able to buy the developed product. Another difficulty is that electrical demand technologies and advanced generating technologies may not seem as important as other U.S. industries in claiming a role in a general high-technology industrial strategy. Current strategies tend to focus on computer, semiconductor manufacture, and biotechnology rather than traditional manufacturing industries. The R&D effort would also have to be designed with care to ensure that the funds are spent productively.

CONCLUSIONS

The scenarios and discussions of the previous section underscore the conclusion that there is no simple key to restoring nuclear power as a national energy option. Nor is there any assurance that even a rigorous set of policy initiatives would do so. Uncertainties over the future growth rate of demand for electricity are at least as important as the policy options analyzed here. At the very least, a moderate demand growth rate and moderate improvements in management of existing plants are prerequisites for creating the conditions under which utilities could consider ordering additional nuclear plants.

The problems and uncertainties are great but not insurmountable. If the technology and its management improve sufficiently that confidence in both safety and economics is much higher, if nuclear regulation shows a parallel improvement, and if financial risks are shown to be less than financial rewards, then nuclear power would be a logical part of our energy future. To see how this might be so, consider the seven sides to the nuclear debate discussed in chapter 1:

- The nuclear industry would have a product that was thoroughly analyzed, demonstrably safe and economically competitive.
- The NRC would have exhaustively examined the design and be confident that few additional issues would be raised once a construction permit had been granted.
- PUCs would have more confidence that a utility would not bankrupt itself with a new reactor because costs would be predictable at the start due to matured designs and regulatory stability, and operation of existing plants had proven to be in the best interests of consumers.
- Investors **could** expect more favorable regulatory treatment from the PUCs as well as having more confidence in the economic attractiveness of nuclear power.
- Critics would have far fewer specific concerns with safety and the overall threat of a “nuclear economy. ” This would lower the intensity of the controversy even if few critics changed their minds on the inherent desirability of nuclear power.
- The public would be more supportive because of the lowered controversy, the improved operating records of existing plants, and the more visible benefits.
- Finally, utilities, or generating entities set up to replace or supplement them, would see this improved environment for nuclear power, the predictability of costs and operations, and the affordability and competitiveness of the new plants, and would be much more receptive to proposals for new nuclear plants.

The purpose of the policy options discussed above is to assist in the transition from the pres-

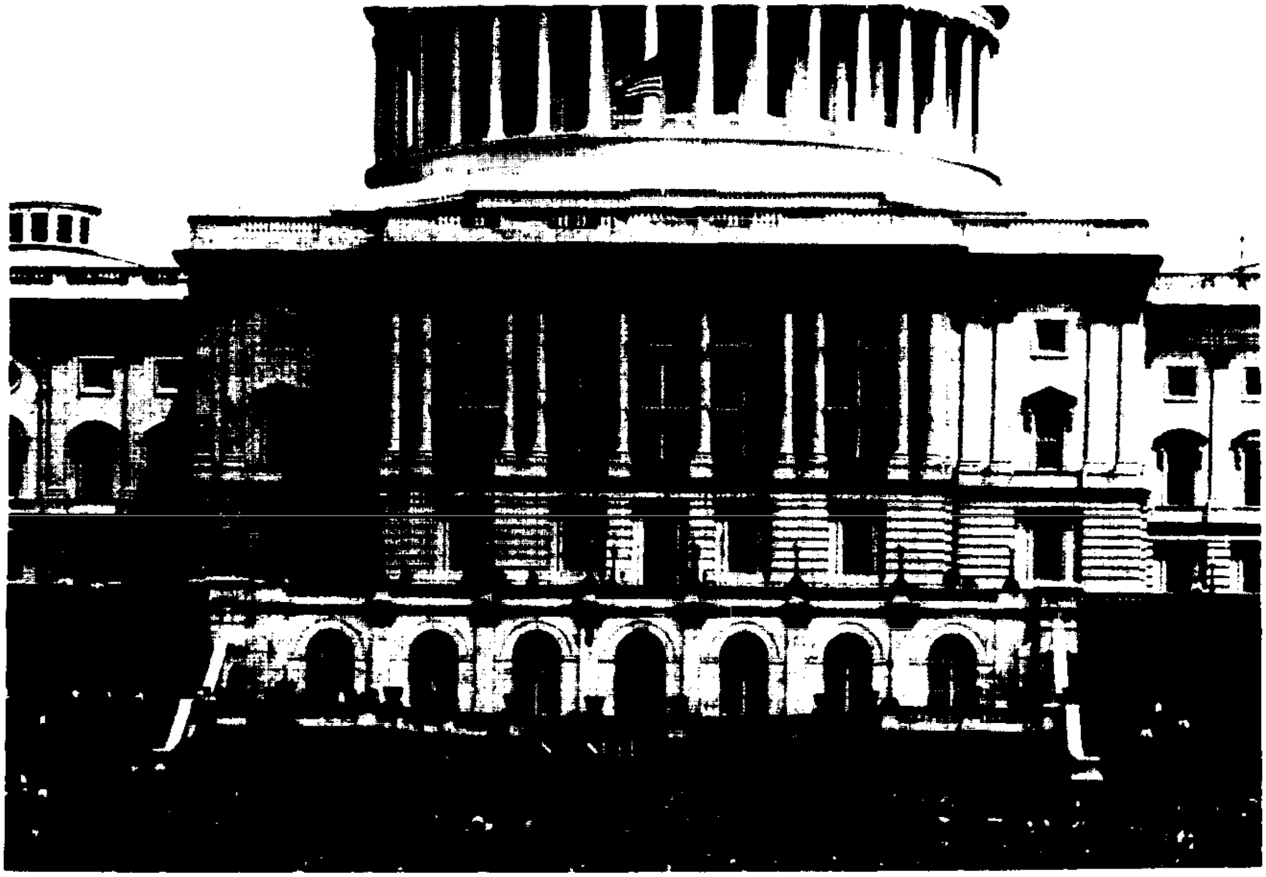

Photo credit: William J. Lanouette

Demonstration in front of the Capitol after the **accident** at Three Mile Island

ent situation to this future. However, it is impossible to say with any certainty how much improvement in any one factor is necessary, or how much each policy initiative would contribute. These problems are interdependent: none can be solved in isolation, but the progress on each will assist in the solution of others.

The future listed above corresponds to Future One in the previous section, coupled with as many policy initiatives as it takes to start nuclear orders. Strategy One might be adequate. Strategy Two probably would be, but we cannot say for sure. The uncontrollable uncertainties are simply too great. For instance, future plants can be designed to be safer than existing plants. industry already is working on this. The national design of Strategy One would improve on this and be more convincing to critics because of the openness of the design effort. The inherently safe reactors of Strategy Two would be more reassuring, but would introduce cost and operational uncertainties. How far is it necessary to go to achieve a consensus that reactors are safe enough? It seems reasonable to assume that greater safety would result in greater acceptance, but there is little direct evidence to support that view or to quantify the relationship.

Any policy strategy should be flexible enough to try things that may not work or may be found inappropriate to changing conditions, and to discard the less successful initiatives in favor of the better ones. The strategy should include elements dealing with the technology, its management, nuclear regulation, financial risk, and public acceptance.

Additional nuclear plants essentially have been rejected by the American people because of perceptions of the current technology and its management. Major improvements will have to be made to restore their faith. To be successful, a strategy must recognize the different concerns and try to balance the interests. In particular, the role of the critics in any nuclear resurgence will be crucial. Critics have been the messengers to the public of many of the real problems with nuclear power. They will continue to play that role until they have been shown that the problems have been solved or rendered inconsequential. They also can be the messengers, even if only by losing interest, when they are convinced that nuclear power as a whole is a minor problem compared to other societal concerns. It is difficult to conceive of how public acceptance can be improved significantly while knowledgeable critics still are voicing real concerns.

The outlook for the nuclear supply industry is bleak but not hopeless. New policy initiatives can set the stage for a turnaround. Without appropriate action, it is likely that the option of domestically produced nuclear reactors gradually will fade away. If such is to be the future, the decision should be made consciously, with the knowledge that even the nonnuclear futures available to the Nation contain risks and drawbacks. Nuclear power can be a significant contributor to the Nation's energy future, but only if the efforts to restore it are undertaken with wisdom, humility, and perseverance.

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