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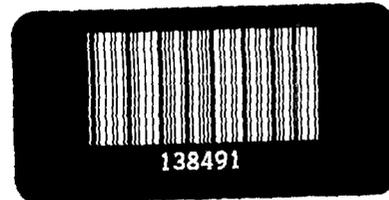
United States General Accounting Office

Report to the Chairman, Environment,
Energy, and Natural Resources
Subcommittee, Committee on Government
Operations, House of Representatives

March 1989

ELECTRICITY SUPPLY

What Can Be Done to Revive the Nuclear Option?



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Resources, Community, and
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March 23, 1989

The Honorable Mike Synar
Chairman, Environment, Energy,
and Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

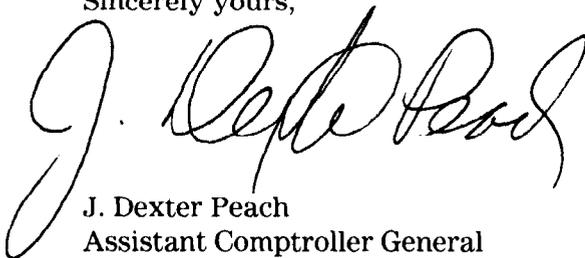
Dear Mr. Chairman:

This report responds to your request to study the future of nuclear power and address matters such as new plant designs and changes to the Nuclear Regulatory Commission's licensing process. The report identifies possible government actions to revive the nuclear option.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies of this report to the appropriate congressional committees; the Director, Office of Management and Budget; the Secretary of Energy; and the Chairman, Nuclear Regulatory Commission. We will also make copies available to others upon request.

This work was performed under the direction of Keith O. Fultz, Director, Energy Issues. Other major contributors are listed in appendix II.

Sincerely yours,



J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

In the 1960s and early 1970s, nuclear power promised to be a safe, economical energy source. However, since then, safety concerns and soaring costs have clouded its future. As a result, the viability of nuclear power as an energy supply option is being increasingly questioned.

Accordingly, the Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, asked GAO to contact nuclear utility managers, government program officials, and other experts to determine the problems of the commercial nuclear power industry, identify possible remedies, and assess the status of federal government efforts to revitalize the nuclear option.

Background

In the 1960s and early 1970s, utilities ordered more than 200 nuclear plants to meet expected electricity demand. At the time, nuclear plants offered economic and environmental advantages over coal plants; most were completed on time and at reasonable cost and still operate today, providing economical, reliable electricity. In the 1970s, a series of events, beginning with the 1973-74 recession and culminating with the Three Mile Island accident, adversely affected the nuclear industry, causing utilities to cancel more than 100 nuclear plants. Those plants that were completed had large cost overruns. As of December 1988, the Nuclear Regulatory Commission (NRC) had issued operating licenses to 110 nuclear plants. These plants, owned by 54 utilities, provided about 20 percent of the nation's electricity in 1988.

The policy of the federal government is to retain nuclear power as an energy alternative because of potential problems with other options. Given the long lead time to complete a nuclear plant—up to 15 years—actions are needed soon if nuclear power is to provide a portion of the new capacity that the Department of Energy (DOE) expects the nation will need by the turn of the century. (See ch. 1.)

Results in Brief

No utility manager that GAO contacted is considering building a new nuclear plant at this time because of increased costs and strong public opposition to nuclear power. Moreover, utilities are generally not planning to build any large electricity generating plants because of the risks and environmental questions associated with coal, the principal alternative fuel. As a result, utilities are purchasing increasing amounts of electricity from small independent power producers and Canada. The nation is also growing increasingly dependent on imported oil. Thus, steps to

revive the nuclear option must be considered against the broader backdrop of forces working to reshape the electric utility industry.

According to experts, reviving the nuclear option requires increased public acceptance and reduced financial risks. The public's concerns about safety need to be allayed through the safe, efficient operation of current plants and improved designs. In addition, escalating costs—stemming in part from an outmoded licensing process and unanticipated actions by state agencies and public interest groups—must be alleviated. Utility executives say progress toward finding a permanent disposal site for nuclear waste is also needed.

The federal government's steps to bolster the industry have generally been ineffective. For example, NRC expects to simplify the licensing process and promote the use of preapproved, standardized plant designs, but these actions have not received legislative support. According to industry leaders, congressional backing is needed to signal a political commitment to keep the nuclear option alive, even though that may not be enough to stimulate new plant orders.

Principal Findings

Economic and Safety Factors Hurt the Nuclear Power Industry

In the 1970s, a series of events negatively affected the nuclear option. First, because of the 1973 oil embargo and the following recession, inflation and interest rates soared, and electricity demand projections fell sharply. Second, serious safety questions arose that led NRC to establish extensive new regulations. Finally, in March 1979, the Three Mile Island accident occurred, solidifying the public's opposition to nuclear power and intensifying NRC's scrutiny of the industry. In the 1980s, instances of poor utility management—in part due to the number of different, complex plant designs—resulted in inefficient operations and questionable safety practices at several plants. (See ch. 2.)

Public Acceptance Problems Beset Utilities

Although opinion polls show that a majority of the public believes nuclear power will play a large role in the nation's energy future, many opponents believe that nuclear power is not safe. This perception, predicated on worst-case accidents, was strengthened by the 1986 Chernobyl accident and by recent revelations about environmental, safety, and health problems within DOE's nuclear weapons complex. Consequently,

the public has opposed new nuclear plants—for example, state and local organizations recently delayed the start-up of two completed plants, Seabrook and Shoreham.

Utility executives believe they have compiled a good safety record and are disappointed by the strong public opposition. They also believe that the continued safe operation of current nuclear plants is critical to reviving the nuclear option and one more serious incident could doom a second nuclear generation. (See ch. 2.)

Many Other Problems Contribute to Financial Risk

In addition to strong public opposition, utility executives say that many other circumstances increase the financial risk of building a new nuclear plant. These include

- a two-step licensing process that allows NRC and intervenors to reenter the licensing process after a plant is built (when changes are very costly);
- state agencies that use their rate-making authority to disallow the recovery of some construction costs; and
- DOE's slow progress toward building a repository for nuclear waste.

Because of these circumstances, utility executives are increasing their reliance on alternatives, such as imported electricity and oil- and gas-powered generators, that raise energy security concerns. (See ch. 2.)

What Can Be Done?

Utility executives believe that progress must be made on a number of fronts. Needed most are continued safe, efficient plant operations that they hope will increase public acceptance, as well as a strong federal nuclear energy policy. According to these officials, new policy legislation should (1) revise the licensing process into a one-step procedure, (2) promote standardized designs, (3) define more clearly the role of state agencies and public interest groups in the licensing process, and (4) promote research and development.

According to DOE officials and nuclear experts, these are necessary first steps to revive the nuclear option. But progress on all these fronts, they caution, still may not make nuclear power economically attractive to utilities or acceptable to the public. (See ch. 3.)

Government's Role Currently Limited

Although the stated federal policy is to maintain the nuclear option, NRC and DOE programs to revive nuclear power have been ineffective. For example,

- NRC and DOE have been promoting licensing reform and standardized plant designs for several years but have lacked congressional support;
- DOE supports private efforts to develop improved reactors, but funding levels are low and do not support the construction of test models; and
- DOE's selection of a waste repository site has been hampered by legal, political, and institutional problems. (See ch. 3.)

Matters for Congressional Consideration

The Congress faces a number of strategic energy decisions. Each electricity supply alternative has related problems and questions. These problems point to a need for a congressional review of the nation's nuclear energy policy within the broad context of the changing nature of the electric utility industry. However, the Congress should realize that although it can take some steps to help revive the nuclear option, its actions alone will probably not stimulate new plant orders.

As it reviews the nation's nuclear energy policy, the Congress should consider enacting legislation to reform the licensing process and promote utilities' use of NRC preapproved designs. The Congress should also reevaluate the goals, objectives, and funding for nuclear research and development.

Agency Comments

GAO discussed the facts presented in this report with NRC, DOE, and utility officials. Generally, they agreed with the facts but offered some clarifications that were incorporated where appropriate. As requested, GAO did not ask NRC, DOE, or the utilities to review and comment officially on this report.

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Abbreviations

AEC	Atomic Energy Commission
DOE	Department of Energy
EPRI	Electric Power Research Institute
GAO	General Accounting Office
INPO	Institute of Nuclear Power Operations
NRC	Nuclear Regulatory Commission
TVA	Tennessee Valley Authority

Introduction

In the 1960s and early 1970s, nuclear power promised to be a safe, economical energy source. Utilities ordered over 200 nuclear plants to meet electricity demand, which was expected to double every 10 years. By 1988, however, the promise was lost. During the 1970s and 1980s, electricity demand slackened, costs soared, and safety concerns increased. Further, because of heightened safety concerns, the government greatly increased its scrutiny of the industry, adding many more regulatory requirements. As a result, utilities canceled over 100 plants, in some cases, after spending billions of dollars on them. Currently, no utility seriously considers nuclear power when contemplating future capacity needs. The future of nuclear power has changed from "too cheap to meter" to "too risky to consider." However, nuclear power is not the only energy supply alternative facing tough problems and challenges. Because of environmental and energy security questions facing other alternatives, the federal government's policy is to ensure that nuclear power remains a viable option for meeting the country's energy needs.

Background

In 1954 the Congress amended the Atomic Energy Act to permit and encourage commercial development of nuclear energy. At that time, the Atomic Energy Commission (AEC) began to issue licenses allowing private companies to build and operate commercial nuclear power plants. The nuclear utility industry received further encouragement in 1957 when the Congress passed the Price-Anderson Act, limiting the liability of utilities in the event of an accident. In 1957 the Shippingport, Pennsylvania, plant became the nation's first nuclear power reactor to produce power for commercial use. The Dresden plant in Illinois in 1960 became the first licensed commercial reactor. By then utilities had ordered 12 nuclear reactors.

At that time, nuclear power plants offered several benefits. Utilities' economic evaluations showed that nuclear power plants competed favorably with coal-fired plants or other options because higher construction costs would be more than offset by lower fuel costs and the net cost of electricity to consumers could be reduced. Further, nuclear power plants produced little atmospheric pollution compared with coal-fired plants. In many parts of the United States, utilities chose nuclear power because of its economic advantages.

Nuclear plants built in the late 1960s and early 1970s were generally completed on schedule and at reasonable cost. All nuclear plants operating by 1970 cost an average of about \$200 per kilowatt¹ of generating capacity. Those larger than 400 megawatts took only about 5 years to build. Many of these plants operate today, providing economical and reliable electricity. Their small size simplified construction, and AEC inspection activity was minimal. By 1968, however, plants offered by nuclear vendors—large manufacturers of nuclear reactors and steam supply systems—were several times larger than those in operation at that time. Utilities, facing an average electricity demand growth rate of about 7.5 percent per year throughout the 1960s, placed 74 new plant orders with nuclear vendors from 1966 to 1969.

During the 1970s, regulatory requirements increased markedly while electricity demand expectations dropped dramatically. For example, a 1971 court case required utilities to file environmental impact statements in compliance with the National Environmental Policy Act of 1969 along with their applications for construction permits to AEC.² In response to growing safety concerns, AEC also issued new regulations that specified design criteria in areas such as seismic protection. Then in 1973 and 1974, the oil embargo caused fuel costs to double and inflation and interest rates to soar. The economy experienced a recession, and demand projections for electricity fell sharply. In 1975, for example, electricity demand did not increase at all, compared with earlier projections of over 7 percent.

In the mid-1970s, serious safety questions also arose, further affecting nuclear reactor orders. For example, in March 1975, a fire seriously damaged safety-related electrical cables at the Tennessee Valley Authority's (TVA) Browns Ferry plant. This led the Nuclear Regulatory Commission (NRC)³ to establish extensive new safety regulations that applied to all plants, including those under construction or in operation. In 1974 and 1975, 19 utilities canceled orders for plants as costs increased and electricity demand projections continued to decline.

Then on March 28, 1979, the Three Mile Island nuclear plant accident occurred. Although no one was injured and no significant amount of

¹A watt is the basic unit of measurement of electricity production. A kilowatt is equal to 1,000 watts; a megawatt is 1,000 kilowatts.

²*Calvert Cliffs Coordinating Committee v. AEC*, 449 F. 2d 1109 (D.C. Cir. 1971).

³In 1975 AEC, which was responsible for both promoting and regulating nuclear power, was abolished. NRC was established to regulate the safe operation of nuclear power plants.

radioactive material was released, it was the first serious accident that greatly affected the public's perception of nuclear power. Further, NRC's scrutiny of the industry became much more intense and its standards much more exacting. In 1970, for example, AEC had just 11 regulatory guides specifying industry actions to meet licensing requirements. As of January 1989, NRC had issued about 370 regulatory guides and over 1,000 information notices, bulletins, and other related information.

In the 1980s, electricity demand growth rates remained low compared with earlier projections, regulatory requirements continued to increase, and plant cancellations mounted. Also, the cost to complete plants begun in the early 1970s continued to increase to many times more than original estimates. Fossil fuel prices dropped, so nuclear plants became less economical when compared with oil- and coal-fired plants. Further, public opposition to nuclear power grew dramatically after the Three Mile Island accident and later the Chernobyl accident. Many interest groups and even states began to oppose the completion and operation of nuclear plants begun earlier in the 1970s.

As of December 1987, the United States still had the world's largest nuclear program, about 25 percent of all plants worldwide. As of December 1988, NRC had issued licenses to 110 nuclear power plants. Power from these plants provided about 20 percent of the nation's electricity needs in 1988. However, since 1978 no utility has ordered a new nuclear plant, and over 100 nuclear plants ordered since 1974 have been canceled or indefinitely deferred. Many of the same economic factors discussed above also affected coal and oil-fired plants, causing utilities to cancel about 90 of these plants in the same period. Further, current nuclear plants are licensed to operate for 40 years, although the industry and the Department of Energy (DOE) are examining ways to extend their useful life.

As stated in DOE's March 1987 energy policy report, Energy Security: A Report to the President of the United States, the government's energy policy goals include ensuring that nuclear energy remains an option for the future. NRC and DOE direct several programs to accomplish this goal and help revitalize nuclear power. NRC, for example, is trying to simplify the licensing process and encourage standard reactor designs. DOE supports advanced reactor design research and development and is responsible for locating and building a nuclear waste repository.

Objectives, Scope, and Methodology

In July 1987, the Chairman, Subcommittee on Environment, Energy, and Natural Resources, House Committee on Government Operations, asked us to study the future of nuclear power and address such matters as NRC's licensing process and new plant designs that could restore the public's confidence in the nuclear industry. To accomplish this, we agreed to (1) identify the problems preventing new initiatives in commercial nuclear power, (2) identify actions that could be taken to revive nuclear power, such as licensing reform, standardized plant designs, and research and development, and (3) determine the status of government and industry efforts to revitalize the use of nuclear power.

To identify industry problems and obtain private sector views on the status and future of the nuclear option, we interviewed vice presidents and other high-ranking officials of seven nuclear utilities, including Duke Power Co. and Commonwealth Edison Co., two of the largest nuclear utilities. We also contacted TVA officials, the large quasi-government utility that manages nine nuclear plants. In addition, we met with the vice presidents in charge of nuclear activities for Combustion Engineering Inc., one of the three major U.S. vendors of nuclear power systems, and Bechtel Group, Inc., the largest architect-engineering firm in the business of building commercial nuclear plants. We also met with officials of many of the nuclear and electric utility professional associations, including the Edison Electric Institute, Nuclear Management and Resources Council, American Nuclear Energy Council, Electric Power Research Institute, and Institute of Nuclear Power Operations.

We met with representatives of three state public service commissions and the National Association of Regulatory Utility Commissioners to obtain their views on utility rate-setting proceedings and their impact on the decision to build new electricity generating capacity. Further, to balance the views of industry officials on the problems and potential use of nuclear power, we met with officials of two organizations that traditionally intervene in the licensing of nuclear power plants, the Union of Concerned Scientists and the National Audubon Society. To obtain information on the financial concerns of the industry, we spoke to the Director, Komanoff Energy Associates, a leading authority on nuclear power costs. Appendix I provides a complete list of the private organizations we contacted.

At each organization we obtained documents detailing program objectives and views on the nuclear industry. For example, we reviewed the 1985 Report of the Edison Electric Institute on Nuclear Power. We also

obtained copies of testimonies these organizations presented to congressional committees, such as the May 1988 statement on advanced reactors presented by an Electric Power Research Institute official before the Senate Energy and Natural Resources Committee. In addition, we obtained documents summarizing the status of reactor design proposals that the General Electric Co. and other vendors have submitted to NRC for certification.

To determine the status of federal efforts concerning the nuclear option, we met with DOE officials in the Office of Civilian Reactor Development responsible for that agency's advanced reactor research and design program. We examined documents outlining the goals and objectives of DOE's program and reviewed DOE's March 1987 energy policy report, Energy Security: A Report to the President of the United States. We interviewed staff within NRC's offices of General Counsel, Nuclear Regulatory Research, and Nuclear Reactor Regulation to determine their efforts to reform the licensing process and facilitate the use of standardized reactor designs. We also reviewed NRC's regulations, policy statements, and proposed rules in these areas, as well as related testimony and proposed legislation. In addition, we met with the Chief of the Policy Analysis Branch of the Federal Energy Regulatory Commission to determine his views on the changing regulatory environment affecting nuclear utilities.

Further, we reviewed many reports and other documents on issues affecting the nuclear option. These included the Office of Technology Assessment's 1984 report, Nuclear Power In An Age of Uncertainty. We attended several hearings on nuclear issues, including the May 24, 1988, hearing on DOE's advanced reactor program held by the Subcommittee on Energy Research and Development, Senate Committee on Energy and Natural Resources. We also attended a May 1988 American Nuclear Society topical meeting on the next generation of power reactors. The conference provided a forum for government and industry officials to express their views on the future of nuclear power. It also provided information on new reactor designs and industry strategies to revitalize nuclear power. In addition, we attended a workshop on electricity supply and future demand sponsored by the North American Electric Reliability Council and the United States Energy Association.

We discussed the facts presented in this report with officials in NRC's Office of Nuclear Reactor Regulation, DOE's Office of Civilian Reactor Development, and nuclear utility officials. They generally agreed with the facts but offered some clarifications that were incorporated where

Chapter 1
Introduction

appropriate. As requested, we did not ask DOE, NRC, or utility officials to review and comment officially on this report. We conducted our work between November 1987 and December 1988 in accordance with generally accepted government auditing standards.

Nuclear Power: A Dying Energy Option?

Many circumstances and problems contributed to commercial nuclear power's current problems, including the sudden drop in expected electricity demand, rising costs, safety problems resulting in increased federal regulatory oversight, and unanticipated state regulatory and rate-making actions. These factors have combined to create strong public opposition to new plants and a high level of financial risk for utilities. Utility managers believe that many of these problems still exist today. Because of the associated risks, no utility official with whom we met contemplates building new nuclear capacity at this time.

Does this situation mean that the nuclear option is dead? One scientist, representing a prominent environmental group, told us that nuclear energy is not viable because it is an unsafe technology. However, industry advocates disagree. They argue that nuclear power has a good safety record and is expected to provide about 20 percent of the nation's electricity. They also say that current industry problems are primarily due to factors unrelated to the technology, such as an unpredictable regulatory process, stretched-out construction times resulting from reduced demand, and, in some cases, poor management. They believe that the technology can compete economically. They also say that because other major energy options are dependent on foreign and/or exhaustible resources with associated environmental questions, nuclear power still could play an important role in the future of U.S. energy supply.

How the Commercial Nuclear Industry Reached Its Present State

When we asked how the commercial nuclear industry reached its present state, nuclear utility officials and other industry experts gave us many reasons. All of them, however, cited one or more of the following as primary causes of the industry's decline:

- a sharp decline in expected electricity demand;
- increased costs, brought about by inflation, construction time extensions, and unanticipated new regulatory requirements;
- public opposition, which grew stronger after the Three Mile Island accident; and
- instances of poor management, resulting, in part, from over 50 utilities building many kinds of plants.

Decline in Electricity Demand

During the 1960s and early 1970s, the demand for electric energy increased at a rate of about 7 percent per year and showed no signs of slowing down. At that rate, utilities expected total demand to double every 10 years. As a result, utilities ordered over 200 nuclear plants to

help meet this demand; most of the plants were scheduled to begin operations during the 1970s.

Then in 1973, the oil crisis caused the price of crude oil to increase sharply, greatly affecting the U.S. economy. In the United States, the high rate of economic growth and the correlated increase in electricity demand stopped. The sudden and sharp reduction in the need for more generating capacity forced utilities to cancel many coal and nuclear power plants that had been ordered. Where plants were not canceled, construction was often stretched out for many years beyond the initially expected completion dates. Table 2.1 shows the decline in expected demand after 1973 and the corresponding number of canceled plants.

Table 2.1: Growth in Electricity Demand and Canceled Nuclear Plant Orders

Years	Average annual growth in demand (percent)	Number of canceled plants
1960-72	7.1	6
1973-82	2.6	91
1983-87	3.3	17

Source: U.S. Council for Energy Awareness and the Edison Electric Institute.

Increased Costs

Utilities need to borrow large amounts of capital to build nuclear plants, and an increasing number of state public service commissions prevent utilities from recovering most construction costs until the plants begin to operate. Therefore, the huge increase in the cost of capital that accompanied the high inflation and interest rates of the late 1970s greatly affected nuclear plant construction projects. Inflation reached 11 percent in 1979 and over 13 percent in 1980, accompanied by interest rates of about 15 percent and 21 percent, respectively. These rates required utilities in some cases to pay over \$1 million a day in interest charges. In addition, many utilities stretched-out construction times as a result of the slowdown in electricity demand, further increasing total plant costs.

The cost of building a nuclear power plant also dramatically increased as a result of new NRC regulatory requirements following the Three Mile Island accident. After the accident, NRC immediately redirected its resources from routine regulatory activities to evaluations of the accident and the development of plans to prevent a similar occurrence elsewhere. For several years following the accident, NRC focused on plants already operating or under construction, requiring them to complete major modifications as a result of the lessons learned from Three Mile

Island. Utility managers say these added requirements and associated construction delays caused huge increases in the projected costs to complete plants and to operate those that were already constructed. Table 2.2 shows the change in average costs and time to construct nuclear plants between 1971 and 1987.

Table 2.2: Average Cost and Completion Times of Nuclear Plants

First year of commercial operation	Cost per kilowatt ^a	Average number of years to complete
1971-74	\$388	6.8
1975-76	564	8.7
1977-80	670	9.8
1981-84	1,644	13.1
1985	2,693	14.4
1986	2,933	^b
1987	3,776	^b

^aCosts are not adjusted for inflation.

^bData not available.

Source: DOE's 1987 report, Energy Security: A Report to the President of the United States, and other DOE information.

Although cost estimates of added NRC requirements are not generally available, in December 1985 we reported that backfits—required modifications to plants that have already received construction and/or operating licenses—could cost an estimated \$90 million at each of the nation's 35 oldest plants.¹ We also estimated that about \$5 billion had been spent on backfitting at all plants through 1982. We went on to point out that although no estimates on the potential benefits of these added requirements exist, some have had questionable safety benefits. In September 1985, NRC revised its backfitting regulation and established the framework for effective backfitting management.²

In addition, many utilities that decided in the early 1980s to complete nuclear projects found themselves facing another financial problem.

¹Nuclear Regulation: Process for Backfitting Changes in Nuclear Plants Has Improved (GAO/RCED-86-27, Dec. 24, 1985).

²NRC amended its backfitting regulation in June 1988. The revised rule states that backfitting will always be required if such action is necessary to ensure that a facility provides adequate protection to the health and safety of the public and is in accord with the common defense and security. Safety improvements beyond the minimum needs for adequate protection will be required only after an analysis determines that the backfit requirement will substantially increase the overall protection of the public health and safety and common defense and security, and the costs are justified in view of the increased safety or protection. (53 Fed. Reg. 20603-20611, June 6, 1988).

Many state utility commissions, wanting to shield consumers from the "rate shock" that results when the cost of an expensive power plant is added to the rate base, did not allow utilities to recover all construction costs of completed nuclear plants. Ratemakers began using "prudence" audits or reviews to determine those plant costs that were prudently incurred and recoverable from ratepayers. However, utility executives told us that no consistent standard exists among states to determine those costs that are considered prudent; therefore, the disallowances are largely at the discretion of individual state commissions.

In some cases, prudence disallowances and other state actions have tested the financial viability of the utility. For example, Georgia Power was not allowed to recover almost \$1 billion of the cost of its Vogtle plant that the state commission concluded was the result of poor construction management practices. In addition, the majority owners of the Seabrook, New Hampshire, plant filed for bankruptcy after the state of Massachusetts successfully delayed operation of the plant by failing to participate in required emergency preparedness plans and a New Hampshire court denied the company's request for a rate increase.

Public Opinion

Public attitudes toward nuclear power have become increasingly negative over the past decade. Throughout the 1960s and mid-1970s, most (over 70 percent) of the U.S. public said they supported nuclear power, but subsequent mishaps and the Three Mile Island accident have had a negative impact. Opinion polls taken after the Three Mile Island accident showed that at least 50 percent of those polled believed that plant accidents were likely. This feeling was reinforced by the Chernobyl accident in 1986, although public opinion experts believe that many people in the United States understand that substantial differences exist between U.S. commercial reactors and the Chernobyl reactor.

Public opposition to nuclear power has also been strengthened by continued problems at individual plants and within DOE's nuclear defense complex. For example, all five of TVA's operating plants have been closed for extended periods at one time or another because of needed plant improvements. As of September 1988, a total of seven plants nationwide was shut down because of management and safety concerns. Further, other problems have emerged at operating plants. For example, a year ago we reported that a December 1986 accident raised questions about

the long-term safety of pipe systems in nuclear plants.³ Since the accident, NRC has identified 34 plants with pipe damage and is determining whether specific regulatory action is needed. In a related area, DOE's aging nuclear defense complex has come under increasing scrutiny because of growing safety and environmental concerns and recent incidents at its production reactors. Although these reactors are significantly different from commercial reactors, nuclear experts emphasize that the public does not always distinguish between the two and, consequently, public acceptance of nuclear power is negatively affected by problems at DOE's defense plants.

Even before the Three Mile Island accident, several public interest groups successfully intervened in the licensing process of individual plants, resulting in delays of at least 1 year. In the past several years, these groups, working with state and local governments, have successfully blocked the start-up of two completed multibillion dollar plants—Seabrook, New Hampshire, and Shoreham, New York—in part by refusing to participate in emergency planning activities. Although the President recently issued an executive order allowing NRC to review and approve emergency preparedness plans without the participation of affected state and local governments, neither plant has yet received a full-scale operating license. Licensing efforts are still proceeding in both cases. However, as noted above, the principal owners of the Seabrook plant have filed for bankruptcy, while the future of the Shoreham plant is uncertain because of legal and political actions by the state, the utility, and local interest groups. Nuclear power advocates say that such manipulation of the licensing process by state and local governments circumvents NRC's licensing authority and was never intended by the Atomic Energy Act.

Despite the proactive steps taken by intervenor groups, recent opinion polls indicate that the majority of U.S. citizens (over 70 percent) believe that nuclear power will play an important part in this country's energy future. However, the "not-in-my-backyard" sentiment runs very strongly throughout the nation, as the Shoreham and Seabrook cases illustrate. Further, many nuclear opponents believe that nuclear power is unsafe.

Nuclear utility representatives say that they are disappointed with the continued strong opposition to nuclear plants in this country. They point

³Nuclear Regulation: Action Needed to Ensure That Utilities Monitor and Repair Pipe Damage (GAO/RCED-88-73, Mar. 18, 1988).

out that no one in this country has ever been killed or injured by radiation released from a commercial plant and that overall the commercial nuclear power industry has a very good safety record, especially when compared with chemical processing and other related industries. In addition, they say that the nuclear industry compares favorably to the coal industry when one considers the hazards of coal mining and the environmental damage caused by these plants. Yet nuclear advocates agree that many opponents judge the safety issue not on historical risk factors but rather on the basis of a worst-case accident. Unfortunately for the industry, the Chernobyl accident proved that the worst case can occur.

Utility officials with whom we met said that much more demonstrable support from the public and the Congress is needed before they will consider building new nuclear plants. In the meantime, they realize they must maintain an impeccable safety record and improve designs so that safety margins are increased and, perhaps just as importantly, are readily demonstrated to the public. One nuclear expert told us that the industry cannot talk in terms of very low accident probabilities when the public has already experienced two serious accidents and when many people act on similar probabilities each week in state lotteries.

Poor Management: Too Many Utilities, Too Many Plants

Utility executives and other nuclear experts emphasize that commercial nuclear technology is very complex and requires a total management commitment to safe plant operations. They say that these management requirements may not have been totally appreciated in the late 1960s and early 1970s, when over 50 utilities turned to nuclear power to supply needed electricity. In response, at least 6 nuclear vendors, 20 architect/engineers, and 26 construction contractors entered the market to supply needed materials and services. Subsequently, nuclear technology changed rapidly, and plant sizes increased. The end result is that 54 utilities manage 110 plants—each having unique design and operating characteristics.

Nuclear experts say that because of the disparity in types of plants, each utility has had to learn “from the ground up” the business of building and operating a nuclear plant. To a large degree, utilities have not had the advantage of standardized construction activities or operator training and maintenance procedures. As a result, wide disparities exist in the costs and times needed to construct individual plants. For example, Florida Power and Light Co. completed its St. Lucie unit 2 plant in 6 years, while Pacific Gas and Electric Co. took over 14 years to complete

both of its Diablo Canyon plants. Further, the diversity and number of utilities that own and operate nuclear plants has resulted in cases of weak or less than adequate management, which in turn has led to safety concerns. For example, NRC ordered the Philadelphia Electric Co. to shut down both units of its Peach Bottom Plant following the March 1987 disclosure of reactor operator abuses, such as employees sleeping on duty. The utility is making management improvements and hopes to restart the plant in 1989.

Past nuclear power studies such as the Office of Technology Assessment's 1984 report, Nuclear Power In An Age of Uncertainty, have tried to define key attributes of utility management practices. That report concluded that no identifiable characteristics exist to distinguish good plant management. For example, one might think that because of available resources large utilities would be more successful nuclear plant managers, and some large utilities, such as the Duke Power Co., are. But TVA, the largest nuclear plant manager, has shut down all five of its operating plants for extended periods since 1985 to resolve safety concerns,⁴ while several small utilities, such as Wisconsin Electric Power Co., have efficiently and effectively managed plants for many years. Nevertheless, most experts agree that in several cases, utility mismanagement or lack of attention to the level of detail required to operate nuclear plants has resulted in poor operations and questionable safety practices.

The impact of utility management on operations is perhaps best reflected in the wide range of plant capacity factors—the ratio of a plant's electricity output to expected output—that occur in this country. Table 2.3 shows the range in capacity factors from 1985 to 1987 for a selected number of plants.

⁴Nuclear Regulation: Efforts to Ensure Nuclear Power Plant Safety Can Be Strengthened (GAO/RCED-87-141, Aug. 13, 1987) discusses other plants that have been shut down to correct significant safety problems.

Table 2.3: Selected Average Annual Nuclear Plant Capacity Factors, 1985 to 1987

Plant	Size of plant ^a	Utility	Annual average capacity factor, 1985 to 1987 (percent)
Kewaunee	535	Wisconsin Public Service Corp.	87.47
Maine Yankee	825	Maine Yankee Atomic Power Co.	84.68
Millstone-1	660	Northeast Utilities	82.77
Beaver Valley-1	833	Duquesne Light Co.	76.80
Calvert Cliffs-1,2	1,650	Baltimore Gas and Electric Co.	75.70
Indian Point-2	873	Consolidated Edison of New York, Inc.	68.97
Catawba-1,2	2,258	Duke Power Co.	61.30
Waterford-3	1,104	Louisiana Power and Light Co.	59.85
Oyster Creek	650	GPU Nuclear Corp.	50.05

^aExpressed in megawatts of electricity.

Source: Federal Energy Regulatory Commission and the U.S. Council for Energy Awareness.

According to NRC staff, many of the regulations and requirements the agency developed throughout the 1970s and following the Three Mile Island accident are now resulting in improved plant performance. They pointed out that overall plant availability and operating statistics have significantly improved in the past 3 to 4 years, and the number of events or "challenges" to the plants' safety systems has dropped by a factor of 2 to 3 in the past several years. NRC staff also credit its active on-site inspection program and the industry's own safety program for these improvements.

Case Study: The Georgia Power Co.'s Vogtle Project

The following brief case history of the Georgia Power Co.'s Vogtle plant illustrates many of the problems that utilities encountered throughout the "nuclear era."

In mid-1971, demand projections led Georgia Power to believe that a four-unit nuclear generating station would be needed in the late 1970s and early 1980s. As a result, Georgia Power's directors authorized the construction of a plant, projected to cost about \$1.3 billion, or \$660 million for each of two paired units. Georgia Power had expected the plants to start commercial operations in 1978 or 1979.

In September 1974, because of financial problems related to the 1973-1974 recession and a drop in expected future demand, Georgia Power suspended design and construction work for the Vogtle project and canceled two of the four units. In 1974 and 1975, almost no growth took place within the Georgia Power system. Subsequently, outside financial participation allowed Georgia Power to reactivate the project. In 1977 construction resumed; however, following the Three Mile Island accident in 1979, more delays occurred as NRC promulgated a series of new requirements that had to be incorporated into the plant's design and construction to improve plant safety.

Vogtle unit 1 began operations in June 1987, 16 years after it was initiated; unit 2 is expected to go on line in 1989. Georgia Power estimates that costs will now total almost \$9 billion. The company attributes about \$2.2 billion of this amount to new regulatory requirements. However, a prudency audit ordered by the Georgia Public Service Commission and conducted between 1985 and 1987 identified certain delays that could have been avoided through proper management of the project. The audit concluded that the Vogtle unit 1 plant should have been constructed in about 82 months rather than 102 months. Following the audit, the commission did not allow Georgia Power to recover about \$950 million of the plant's costs from its customers.

Current Industry Views on the Nuclear Option

Industry evaluations show that nuclear power can still compete economically with coal- or oil-fired plants. However, representatives of electric utilities, utility trade organizations, nuclear contractors, and public utility commissions told us that under present and foreseeable conditions nuclear power will not be selected as replacement or new generating capacity for several reasons, including public opposition, regulatory uncertainty, and economic risk.

These reasons are interrelated. In the past, new NRC requirements have often been imposed on existing plants and plants under construction, which greatly increased costs. Further, under the current licensing process the utility cannot obtain an NRC operating license until after the plant is constructed. At that time, NRC, intervenors, or the state may try to place additional requirements on the utility or even try to prevent it from operating. Therefore, the utility decisionmaker can predict neither the amount of time or money needed to meet licensing or operational requirements nor the requirements that NRC might add after construction begins but before the plant generates revenues. Even after the utility obtains a license, recent experience shows that the state may not

allow it to fully recover incurred costs. Thus, public opposition and an unpredictable nuclear licensing process help create an unacceptable economic risk for utilities considering a new plant.

As a result of various factors, utilities have canceled or indefinitely deferred all nuclear plants ordered since 1974 and are not planning to build any new ones. Further, most utilities are postponing any large expansions of capacity because of environmental questions associated with other alternatives. Therefore, many utilities are adding only small incremental units to their capacity or looking to outside sources for additional power.

Utilities Are Not Building New Capacity

Most utilities are not planning to add any significant new capacity even though electricity demand is increasing. On the basis of expected demand requirements, DOE predicts in its 1987 Energy Security Plan that over 100,000 megawatts, or about 100 new base-load plants, will be needed by the end of this century.⁵ In 1987 annual electricity demand rose by 4.5 percent, up from an average of 3.3 percent in the 1982 to 1986 period, and experts predicted an increase of more than 4 percent in 1988. However, most utilities are not building any significant new capacity, including coal- or oil-fired plants, because of environmental questions and related risks. One utility official claims that today's legislative and regulatory environment drives utilities to focus on short-term economics rather than the long-term advantages of large base-load plants, which require 10 to 15 years to plan and construct.

As a result, utilities that are adding new capacity are usually building only small generators fueled by gas or oil to meet peak demand. These units are generally expensive to operate, plus they raise energy security concerns since many of them are oil-fired plants. In 1988 the nation's use of imported oil increased, representing about 42 percent of all U.S. oil consumption.

Utility executives are also meeting growing demand by buying electricity from other producers. For example, those in the northeastern and north central states are buying increased amounts of electricity from

⁵Utilities generally maintain a mix of large coal or nuclear plants and smaller generating facilities. The large base-load plants meet the bulk of electricity demand and are rarely shut down. The smaller, more flexible generating facilities are operated when demand peaks, such as during a hot summer day.

Canada. Sales of Canadian power to the United States more than quadrupled from 1976 to 1986, growing at an annual rate of about 9.5 percent. Utilities also buy electricity from unregulated (i.e., non-rate-based) producers. In fact, the Public Utility Regulatory Policies Act requires utilities to buy electricity that is offered by small independent power producers and cogenerators—companies that produce excess electricity while making other products—at the price it would cost the utility to produce or otherwise obtain the power. Much of this electricity is also generated through oil- or gas-powered generators.

A recent report by the North American Energy Reliability Council stated that about 24,000 megawatts, or 4 percent of the nation's generating capacity, is owned by independent producers and another 28,000 megawatts is planned or under construction. A Federal Energy Regulatory Commission official expects this source of electric energy to become more prevalent and estimates that more than 10 percent of the electricity consumed in California, the leading state in this area, is produced by cogenerators and small producers. In addition, in March 1988 the Federal Energy Regulatory Commission proposed regulations that would further encourage independent power producers. As of January 1989, the Commission was reviewing numerous public comments received on the proposed regulations. The proposed regulations would relieve small independent producers from complying with many requirements that apply to larger rate-based producers engaging in interstate electricity commerce.

Virginia Power was one of the first utilities to announce that it plans to rely on purchased power to satisfy added capacity needs. In March 1988, Virginia Power announced plans to auction construction rights to outsiders for 1,750 megawatts of new capacity. Early in 1989, the utility signed contracts with 19 alternative generating facilities for almost 2,100 megawatts of capacity. If all of this is eventually produced, about 20 percent of Virginia Power's overall generating capacity will come from outside sources.

Industry and Federal Efforts to Keep the Nuclear Option Alive

Government and industry officials see the current halt in nuclear plant orders as a window of opportunity to rectify many of the industry's problems. DOE says these problems must be solved because nuclear power is needed to provide for continued growth in the use of electricity, which is tied to increases in U.S. productivity, world trade, and living standards.

DOE estimates that by the year 2000 the nation will need about 100 new plants generating 1,000 megawatts each in addition to those plants under construction to maintain an adequate electricity supply. According to a DOE report, if some of these new plants are not nuclear, the United States will be using more oil, paying more for each barrel of it, and feeling much less secure about the energy outlook. However, utility officials say that no nuclear plants will be ordered in the foreseeable future unless a number of economic, regulatory, and political changes occur. What is needed, they say, is increased public and congressional support and an aggressive nuclear energy policy that addresses these issues "across the board."

The federal government's nuclear energy policy, as stated in DOE's March 1987 Energy Security Report to the President of the United States, is to ensure that (1) existing nuclear power plants continue to operate safely and efficiently, (2) plants under construction are completed on time to permit their needed contribution to the national energy economy, and (3) nuclear energy remains an option for the future. To accomplish the last objective, DOE is pursuing a number of research and development programs in cooperation with the private sector, while NRC is trying to revamp its licensing process.

Utility and Industry Views on Needed Actions

Nuclear utility officials and industry representatives told us that a number of interrelated actions are needed to revitalize the nuclear option. These actions include

- the continued safe and improved operation of existing plants;
- licensing reform that results in a predictable, "one-step" process for the industry;
- reactor improvements and standardized designs;
- progress on a nuclear waste repository;
- resolution of state regulatory uncertainties; and
- improved public understanding and support for nuclear power.

Utility officials and other nuclear experts agree that an important link exists between the safe operation of existing plants and a viable future nuclear option. These officials say that another significant accident in the United States would effectively doom the nuclear option for many decades. Further, they agree that utilities must show that existing plants can operate safely and efficiently in order to (1) improve the public's perception of nuclear power and (2) economically justify choosing nuclear power. According to some experts and scientific journals, enough information exists to indicate that some correlation can be made between safety and plant performance. One industry official told us that efficient nuclear plants are usually safer. However, some experts caution that this may not necessarily be true. They say that some utilities may operate their plants with a greater emphasis on availability (ratio between the hours that a plant was available to operate and the hours that it actually operated) than safety.

In 1980 the nuclear utility industry established the Institute of Nuclear Power Operations (INPO) to promote the highest levels of safety and reliability in plant operations. All nuclear utilities are INPO members and accept a form of peer review. INPO evaluates nuclear plants and establishes guidelines for plant operation, operator training, and other areas. It also established a National Academy for Nuclear Training in 1985 to promote the professionalism of nuclear plant personnel. Industry officials claim that as a result of INPO's efforts, nuclear plants have improved their operations in key areas. For example, significant reactor events as defined by INPO have declined by a factor of almost 4 since 1981, and unplanned plant outages have declined steadily since that time.

Although the industry claims that operations have improved from a safety viewpoint and the efficient operation of many nuclear plants has saved customers billions of dollars, in the last several years at least 12 U.S. plants have been shut down for extended periods to correct a wide range of problems. As of October 1988, at least seven plants were shut down because of safety or management concerns. For example, TVA, which holds operating licenses for five nuclear plants and has four more under construction, shut down all operating units in 1985. TVA restarted the Sequoyah plant in 1988, but the other plants will remain closed until safety concerns are resolved.

Need for an Aggressive Energy Policy

Nuclear utility officials cautioned us that progress on any one of the steps listed above would not have a measurable impact on enhancing the nuclear option. What is really needed, utility officials say, is a combined effort directed by an aggressive energy policy and backed by congressional leadership. This in turn would help provide the impetus to sustain the infrastructure of scientists and engineers needed to maintain the nuclear option. Currently, some industry and academic officials are concerned that the nation's brightest students, scientists, and engineers are transferring their talents to other areas because of the current halt in nuclear plant construction.

For example, NRC staff and others believe that one-step licensing is allowed by the Atomic Energy Act, but a utility spokesperson told us that utilities would not initiate any licensing actions until new legislation shows that the Congress supports this process. They also believe that one-step licensing, if and when it becomes the accepted process, would not alone spur new plant orders. Although the economic risk associated with new plants would be lessened by a one-step licensing process, one utility official says that his company would also need assurance that states will not arbitrarily disallow the recovery of plant costs or disrupt the final plant approval process by refusing to participate in emergency planning procedures. The latter action has prevented the operation of the multibillion dollar Seabrook and Shoreham plants.

Several industry leaders summarized their views by emphasizing the need for a comprehensive energy policy that identifies nuclear power as a valuable long-term option and implements necessary regulatory improvements to eliminate delays and uncertainty. One official said that these changes should stabilize regulatory and rate recovery actions, thereby enabling timely construction of nuclear plants and restoring investor and lender confidence. However, nuclear experts are quick to point out that progress on all these fronts may not make nuclear power economically attractive or acceptable to the public relative to other options. But they believe these are necessary first steps, given current environmental and energy security questions associated with other alternatives.

Federal and Commercial Efforts to Keep the Option Alive

The federal government, led by NRC and DOE, is pursuing a number of programs to revitalize nuclear power. On some of these efforts, such as DOE's advanced reactor research and development program, the government is working with the private sector. Other ongoing federal programs, such as the deployment of long-term waste management systems, are the government's sole responsibility.

The Congress has also recently addressed a number of specific issues that need to be resolved before the nuclear option is seriously considered. For example, in December 1987, it amended the Nuclear Waste Policy Act directing DOE to evaluate only one potential repository site, and in August 1988, it extended the Price-Anderson Act, providing government compensation and limiting the liability of utilities in the event of a nuclear accident. However, several other nuclear matters await congressional attention. For example, a number of bills were introduced in the 100th Congress to restructure NRC, reform the licensing process, and redirect DOE's nuclear reactor research efforts. The Congress did not take final action on these legislative proposals.

Licensing Reform and Standardized Designs

NRC has been working for several years to reform its lengthy, complex licensing process for new reactors. Currently, the process requires two steps: a utility obtains a construction permit and then, after construction is complete, an operating license.

The process starts when the utility files an application for a construction permit—generally 10 or more large volumes of material. NRC then performs separate safety and environmental reviews of the proposed design, producing an environmental impact statement and a preliminary safety evaluation report. NRC also performs a separate antitrust review and evaluates the utility's plans for safeguarding the plant and preventing the diversion of nuclear materials for weapons purposes. Next, the Advisory Committee on Reactor Safeguards, an independent group established to advise NRC on the potential hazards of reactor facilities, conducts a safety review. Following the committee's review, a three-member Atomic Safety and Licensing Board conducts a mandatory public hearing on the feasibility of granting the permit. The Atomic Safety and Licensing Board's decision is subject to appeal before the Atomic Safety and Licensing Appeal Board and then could go to NRC's commissioners for a final decision. To obtain an operating license, a similar process is followed to determine whether the plant has been built to specified standards and whether the applicant is qualified to operate it.

Utility officials have long complained that this process unnecessarily subjects them to undue financial risk because they do not have assurance that they will be allowed to operate a plant after they have invested billions of dollars in construction. They state that a separate review for an operating license allows NRC and intervenors to reenter the decision-making process at a point when even small changes can cost large amounts of money. In a 1978 report,¹ we agreed that the license review process should be flexible enough for NRC to perform a one-stage application review. At that time, 40 percent or more of the operating license review duplicated activities performed during the construction permit review. Our report also pointed out that a one-stage review depended on the availability of final design information.

Some experts now say that the lack of final design information and the nuclear plant construction process that existed throughout the 1960s and 1970s made the two-step licensing process necessary. Utilities were routinely issued construction permits before final designs were determined, and the regulatory process was evolving as the nuclear industry grew and designs advanced. Further, the 1979 Three Mile Island accident accentuated the need for additional regulations for safety reasons. Therefore, under the circumstances it was reasonable for NRC to identify new requirements that needed to be incorporated in plants under construction. They also say that the present halt in construction and plant orders provides an opportunity for the industry to define plant requirements and develop standardized designs.

NRC, DOE, and the utilities support a one-step licensing process that would eliminate duplication and encourage the use of preapproved standardized plant designs. Under this process, a utility can obtain early NRC approval for a plant site and then submit to NRC for review a complete, detailed design and plan for a new plant. Upon approval, NRC would grant the utility a combined construction and operating permit. After the combined permit was granted, NRC would ensure through inspections and quality assurance reviews that the plant was built to design specifications. The public would have complete access to the licensing process but would be required to show significant cause before a hearing could be initiated after construction began. Thus, a utility would be assured that if it built the plant according to the original approved designs, it would be able to operate the plant.

¹Nuclear Powerplant Licensing: Need For Additional Improvements (EMD-78-29, Apr. 27, 1978).

According to NRC and DOE officials, the key component of a one-step licensing process could be the development of standardized plant designs that would be approved and certified by NRC in advance of a utility license application. Then, when a utility decided to build a plant, it could select a vendor that already had the plant design certified and avoid the time required by NRC to review a plant design before construction began. The public would participate in the review and approval of the design. Variations to the design required by site-specific requirements would also be subject to NRC and public review. According to utility executives, one-step licensing combined with standardized designs would greatly reduce the lead time now needed to plan and build a new nuclear plant as well as compress the time a utility has to financially commit to a new plant.

NRC has taken several actions to develop a one-step licensing process and encourage standardized designs. In 1987 NRC (1) revised an existing standardization policy statement, (2) outlined at a public meeting a design certification process, and (3) proposed legislation to amend the Atomic Energy Act to specifically allow a one-step review process using standardized designs. In the introduction to the policy statement, NRC states that the use of certified standardized designs would protect the public health and safety by (1) concentrating resources on specific design approaches; (2) stimulating standardized programs of construction practice, quality assurance, and personnel training; and (3) fostering more effective maintenance and safe plant operations. In strongly endorsing the concept of standardization, NRC acknowledges that drawbacks exist. The most significant is that specific problems may potentially affect a large number of plants.

NRC staff believe that many of the proposed licensing and standardization reforms can be accomplished under existing statutory authority. As a result, in October 1987, NRC outlined at a public meeting a design certification process and in August 1988 issued proposed regulations for public comment. NRC expects to issue final regulations by March 1989. In the interim, NRC has been reviewing standard reactor designs submitted by the three major nuclear vendors—General Electric Co., Westinghouse Electric Corp., and Combustion Engineering Co.—with the intent of issuing design certifications. NRC expects to certify General Electric's advanced boiling water reactor design in late 1991 and Combustion Engineering's and Westinghouse's pressurized water reactor designs in late 1992 and mid-1993, respectively.

Although NRC believes its authority allows one-step licensing and is proceeding to develop regulations to that effect, NRC and DOE, like the industry, believe that the Congress needs to support this effort by enacting standardization and licensing legislation. An industry representative told us that utilities would be reluctant to pursue a certified design through a one-step process until the Congress supports the process with new legislation. For the past few years, DOE and NRC have supported legislation that would allow NRC to issue a combined construction permit and operating license and initiate a reference design certificate approval process. However, the Congress has not yet approved the legislation.

Public interest group representatives with whom we met were divided on the prospect of one-step licensing. One official, representing the National Audubon Society, stated that one-step licensing was just a mechanism to restrict the public's involvement in the licensing process. However, a representative from the Union of Concerned Scientists said that one-step licensing, if accompanied by truly complete designs and plans that were carefully followed, would be a significant improvement. The scientist said that under the 1970s "design-as-you-build" process, the public and responsible intervenors had problems finding out and documenting safety systems built into the plants. He also pointed out that under that system, suggested changes made when the utility requested an operating license often had large cost repercussions, causing utility officials to strongly resist needed changes. This official said that under the one-step process, needed improvements were more likely to be incorporated at the design stage.

Research and Development
Efforts

Some experts believe that the nuclear option will not be revived until reactor designs incorporating more passive safety systems are suitable for commercial construction. They define such reactors as "forgiving" of human error and certain external events and capable of shutting themselves down through the use of passive cooling systems should unusual conditions occur. Passive cooling systems depend on gravity or other naturally occurring forces rather than on human action or electric pumps and motors. Thus, the reactor would be protected from human error or electricity failures. Several passively safe reactor designs have been proposed. For example, the Swedish Process Inherent Ultimately Safe reactor would be completely immersed in water. In the event of an accident, the coolant (water) would automatically shut the reactor down.

Other experts with whom we met say that no totally safe reactor can be built. They argue that radical new plant designs with totally different fuel and new cooling systems require long-term testing and prototype plants that no one wants to fund. Further, DOE and industry experts agree that if nuclear power is to contribute to the nation's near-term energy needs, existing light water reactor technology with improved safety features will most likely provide the basic designs for new plants. They also say that the U.S. commercial industry, which has accumulated almost 1,000 years of operating experience with these plants, would not accept totally new untested designs.

DOE manages the government's nuclear research and development efforts. In fiscal year 1989, DOE expects to spend about \$353 million for nuclear research, excluding nuclear fusion and nuclear waste technology research. Of this amount, DOE plans to spend about \$4 million on efforts to extend the life of current reactors, \$80 million on advanced reactor designs, such as a high-temperature reactor that uses helium gas as a cooling agent, and \$27 million on an improved light water reactor design program.

DOE's advanced reactor design program supports the development of alternative designs and fuel cycles that have the potential for breakthroughs in economics, safety, licensability, and waste management options. The primary emphasis of the program is to support continued work on innovative liquid-metal and high-temperature gas-cooled reactor designs. Program officials do not plan to build any commercial prototype reactors once designs are finalized, although DOE may build a high-temperature, gas-cooled reactor for defense production.

DOE closely coordinates its light water reactor program with the nuclear utilities' research association, the Electric Power Research Institute (EPRI). EPRI was formed in 1973 to perform research for member utilities. Currently, 46 of the nation's 54 nuclear utilities are EPRI members. EPRI's light water reactor program began in the early 1980s. Under the program, owners and operators of nuclear plants are determining the characteristics and performance parameters new plants will have to meet. In the process, they expect to encourage standardized plant designs that meet collectively agreed-upon requirements. To accomplish this, EPRI is preparing a Utilities Requirements Document that will provide detailed safety, environmental, and operating requirements pertaining to the performance and design of an evolutionary light water reactor design, which incorporates many passive safety systems.

While preparing the Utilities Requirements Document, EPRI established the following principles to govern the development of new designs.

- **Safety:** A primary emphasis of the design will be on lowering the risk of a core-damaging accident.
- **Simplicity:** The design should reduce dependence on electrical systems and mechanical components to achieve safety and increase dependence on improved plant design and passive safety systems, such as natural circulation and increased coolant supplies.
- **Design margin:** The design will be “forgiving” of human error and will also afford the operator time to fully assess and deal with unusual conditions without jeopardizing or causing major damage to the plant.
- **Human factors:** The design will recognize that the weakest link in the nuclear safety chain is the man/machine interface and take advantage of recent advances in human factors engineering.

In addition, DOE and EPRI expect the program to promote improved economic parameters in new light water reactor designs. In particular, it will require that new designs have better operating availability (at least 87 percent), a longer design life (60 years, compared with the current 40 years), and lower waste production. EPRI has also determined that the new plants will have to be built in 4 years or less to limit capital costs and reduce utilities’ financial risks to an acceptable level.

Although EPRI’s program will not result in a unique plant design, EPRI is coordinating its efforts with two of the vendors pursuing design certification with NRC—Combustion Engineering and General Electric—and has commitments from these companies that their design applications will meet the majority of the parameters set out in EPRI’s requirements document. EPRI has also submitted the initial volumes of its requirements document to NRC for review. NRC plans to complete its review by 1990 and, if it endorses the requirements document, issue a safety evaluation report. DOE hopes that its light water reactor program will result in NRC’s certifying a standardized reactor design by 1991 that meets EPRI’s requirements.

DOE is also cooperating with an industry-led program to develop requirements for a midsize (about 600 megawatts) light water reactor that would depend more heavily on passive safety systems. DOE believes that midsize plants may fit more easily into the capacity planning schemes of most U.S. utilities. Also, smaller plants offer a potential for shorter construction time and extensive modularization of plant equipment. EPRI

has chosen two potential plant designs from an initial design competition. DOE plans to decide by 1989 whether these plants would be attractive to utilities; if so, it will work with EPRI to develop a detailed design that can be certified by NRC by 1995.

The Congress also considered legislation to redirect DOE's nuclear research and development program. S. 2779, introduced in September 1988, would have authorized construction of a small (400- to 600-megawatt) commercial nuclear reactor demonstration project using passive safety features. The bill would have required DOE to choose the design through a competitive selection process and build the reactor by 2003. It would have also authorized appropriations of up to \$500 million over the first several years of the program for construction, with 50 percent of the cost to be provided by the private sector. Although the bill did not pass, DOE expects it to be reintroduced in the next session of the Congress.

Nuclear Waste

Many utility officials and other experts told us that no nuclear plants will be built in this country until the nuclear waste disposal problem is resolved. Currently, utilities store highly radioactive waste (spent fuel) from reactor operations in large water pools at reactor sites. For years, policymakers have struggled to find a permanent solution to the waste disposal problem. Further, nuclear power critics argue that no new plants should be started until a permanent, safe disposal site is found.

After much debate, the Congress passed the Nuclear Waste Policy Act of 1982. The act established a federal program and policy for high-level radioactive nuclear waste management with the ultimate objective of providing safe and permanent disposal of nuclear waste in geologic repositories. The act also established a systematic site selection and review process that involves affected states and Indian tribes and required DOE to site and construct the nation's first repository by 1998. To finance the program, the act established the Nuclear Waste Fund, which receives fees from waste owners and generators. Under various assumptions, DOE estimated that program costs would be about \$33 billion or more (1987 dollars).

However, the site selection process for the first repository established by the act has been beset by various legal, political, and institutional problems. States, Indian tribes, and local groups continually resisted DOE efforts to proceed with the site selection process. In addition, they filed over 40 lawsuits protesting site selection activities. As a result, DOE has

been unable to meet virtually any of the act's milestones for the first repository. Nevertheless, in May 1986, DOE recommended to the President three candidate repository sites for detailed geologic testing (site characterization). On May 28, 1986, the President approved the three sites—Yucca Mountain, Nevada; Deaf Smith County, Texas; and Hanford, Washington—for characterization. On the basis of the results of site characterization, DOE planned to select one of the three sites for a nuclear waste repository. In September 1987, we reported that when the effect of future inflation was considered, site characterization costs could total about \$5.8 billion for the three sites.²

In December 1987, the Congress reacted to the continuing problems in the program's site selection process by enacting the Nuclear Waste Policy Amendments Act. The amendments substantially changed the manner in which DOE conducts its nuclear waste disposal program. Most important, DOE was directed to terminate all site-specific activities at the Hanford and Deaf Smith sites and to test and evaluate (characterize) only the Yucca Mountain site in Nevada. Further, subject to existing licensing requirements, a nuclear waste repository is authorized to be sited and constructed only at Yucca Mountain. Site characterization activities to determine the suitability of the Nevada site are expected to take at least 5 years. Because of these changes, DOE expects that future program cost estimates will be significantly lower than its previous estimates.

DOE issued a site characterization plan for the Nevada site in December 1988. According to the plan, DOE expects to begin work there sometime late in 1989. However, Nevada officials have continually criticized DOE waste program activities and are expected to keep trying to prevent the siting of the waste repository in the state. Thus, the final decision to locate the repository largely depends on (1) the findings of the detailed geological work to be performed and (2) the disposition of Nevada's challenges to the site selection process. If the site is found suitable, DOE officials expect to obtain construction authorization from NRC and begin building the repository in 1998. DOE expects construction of the initial phase of the repository to take at least 5 years. Therefore, even if site characterization and construction proceed as scheduled, utilities will not be able to ship waste to the repository until at least 2003.

²Nuclear Waste: Information on Cost Growth in Site Characterization Cost Estimates (GAO/RCED-87-200FS, Sept. 10, 1987).

Conclusions

In the 1960s and early 1970s, nuclear power promised to be a safe, economical way to produce electricity. However, changing economic conditions and safety concerns—caused by the 1973-1974 recession, the Three Mile Island accident, and other events—undermined nuclear power's role. Utility managers currently do not consider nuclear energy to be an option when planning for new electricity generating capacity. More important, utilities are generally not planning to build any large generating plants because of the financial risks and environmental problems associated with alternative technologies. Utilities also face increased competition from small electricity cogenerators and independent power producers because of increased federal incentives provided to them. Thus, specific steps to revive nuclear power have to be considered against the broader backdrop of forces working to reshape the nation's utility industry.

Within this context and considering the long lead time needed to construct a nuclear plant, the time is ripe for the Congress to reconsider the nuclear option. Two key events must take place before the nuclear option is seriously considered by the nation's utilities. First, nuclear power must receive increased public support. Second, the financial risks associated with a new nuclear plant must be reduced. Given the complex nature of these concerns, it is unlikely that congressional action alone will provide for the return of the nuclear option; but the Congress can take some needed steps, such as facilitating the use of standardized reactor designs and supporting licensing reform, to help revitalize it.

Nuclear Power's Public Acceptance Problem

Although the public generally believes nuclear power will play a prominent role in the nation's energy future, states and other public groups have strongly and successfully opposed the licensing and operation of individual plants since the Three Mile Island accident. Those opposing nuclear power generally perceive that these plants are unsafe. This perception stems from worst-case accident scenarios and has been reinforced by the Chernobyl accident, the shutdown of several U.S. plants because of management and technical problems, and problems throughout DOE's nuclear production facilities.

However, nuclear utility managers believe that the industry has a good safety record and point to a number of indicators demonstrating that overall plant performance has improved in the 1980s. They recognize, moreover, that the continued safe and efficient operation of current plants is the most important factor needed to increase public acceptance and support. They also believe that another significant safety-related

event or accident would surely end any hope of new nuclear plant orders.

Increasing public acceptance through continued safe and efficient operation is also needed to reduce the financial risks associated with ordering a new nuclear plant. As demonstrated in New York and New Hampshire, state and local groups have prevented completed plants from operating. Utilities are reluctant to invest in new nuclear plants because of the likelihood that similar actions may occur in the future.

Other Factors Also Raise the Risk of Nuclear Power

Some industry studies show that nuclear power can be cost competitive with other alternatives. However, utility officials and nuclear experts agree that a number of problems create an unacceptable level of financial risk for the nuclear option. In addition to the potential for public opposition, a two-step licensing process, unpredictable state rate-making actions, and the lack of significant progress toward a permanent solution to the waste disposal problem discourage new plant orders.

In particular, the current licensing process, which evolved in the 1970s when utilities did not have complete designs before beginning construction, allows intervenors, state agencies, and others to reenter the license approval process after billions of dollars have been spent on construction. DOE and NRC agree that a change is needed. For several years, both agencies have supported a one-step licensing process to be used with preapproved standardized plant designs in an effort to reduce the complexity and cost of the current licensing process.

Further, unpredictable state rate-making actions and the lack of a permanent waste repository increase the risk of pursuing a new nuclear plant. State commissions often limit a utility's recovery of construction costs because of the "rate shock" associated with an expensive nuclear plant. In addition, utilities and others are concerned about DOE's slow progress toward siting and building a permanent repository for nuclear waste. The lack of a repository is a key argument used by many groups against new nuclear plants.

The Congress' Role

Because of the risks involved, utilities are delaying the construction of all large base-load electricity plants, even though DOE estimates the country will need significant new generating capacity by the year 2000. Rather, utilities are buying more electricity from Canada, purchasing more power from small independent producers, and/or building small

gas- or oil-powered incremental capacity units. This situation causes experts to be concerned about the country's growing dependence on foreign oil. One utility official claims that today's legislative and regulatory environment drives utilities to focus on short-term economics rather than the long-term advantages of large base-load plants.

As a result, the Congress needs to make hard choices as the nation faces the need for increased electricity generating capacity. Each energy alternative comes with its own set of problems and questions. The environmental consequences of burning fossil fuel and the growing need to import larger and larger quantities of oil are arguments supporting steps to maintain the nuclear energy option. However, the government's programs to revive nuclear power have been ineffective. For example, NRC has been slow to reform the licensing process; DOE is spending relatively little for research and development on the next generation of nuclear reactors; and the DOE nuclear waste program has been delayed by institutional problems. Further, the Congress has taken few steps to encourage the nuclear option. Although it recently revamped the nuclear waste program, the Congress has not acted on any of the proposed legislation to revise the licensing process or stimulate research in new plant designs.

Because existing problems and conditions undermine the government's policy of maintaining the nuclear option, the Congress should consider reviewing the nation's nuclear energy policy and the programs needed to implement it. Specifically, we believe that the Congress needs to review the nuclear licensing process with the triple objectives of (1) making the process more predictable, (2) allowing all interested parties to review the safety of proposed designs, and (3) ensuring that plants are constructed as planned. A one-step licensing process combined with the use of certified standard designs could accomplish these objectives and substantially reduce the financial risks to which utilities are subjected under the current process. Although NRC has proposed regulations to simplify the licensing process and facilitate the use of standardized designs, congressional action is needed to demonstrate a national policy in support of nuclear power and encourage future plant orders. Currently, utilities are not sure that they will be allowed to operate completed plants even after billions of dollars have been spent on construction. Standard plant designs would also allow reactor managers to standardize maintenance procedures and training activities, thereby contributing to the safe operation of all plants. However, standardized plants are not without a weakness: should a design defect be identified, it could affect a great number of plants.

If it decides to review the goals of the nation's nuclear energy policy, the Congress could also consider the level of resources for light water reactor research and development. The federal government currently provides relatively little support for advanced light water reactor research and development, generally believed to be the technology that will provide the next generation of nuclear power. Further, it does not anticipate funding the construction of prototype advanced reactors, although one such technology may be used to meet defense production needs.

The Congress also needs to closely monitor DOE's progress in implementing the Nuclear Waste Policy Act. Progress toward locating and constructing a disposal site has been delayed for years by institutional problems. Further delays in the final resolution of the waste question may prove to be nuclear power's "Achilles' heel," effectively ending all future consideration of the nuclear option.

Finally, the Congress should realize that its ability to revive the nuclear option is limited, and action in one area alone—such as licensing reform—may not encourage new nuclear plant orders. Utility officials and other experts believe that a comprehensive effort addressing many areas is needed and, most importantly, the utilities must demonstrate safe and efficient operations of today's plants. Further, they warn that these efforts may or may not bring about increased public acceptance of nuclear power and the reduced financial risks needed before new plants are ordered. However, they argue that the potential benefits of the nuclear option call for immediate action.

Matters for Congressional Consideration

Congress should review the nuclear option within the broad context of the nation's energy security concerns and the changing nature of the electric utility industry. As it reviews the nation's nuclear energy policy, the Congress should consider enacting legislation to reform the licensing process into a more predictable procedure and promoting utilities' use of NRC preapproved standardized designs. It could also reevaluate the goals and objectives of existing federal nuclear research and development efforts.

Utilities and Other Organizations Contacted During This Review

Utilities

Baltimore Gas and Electric Co.
Carolina Power and Light Co.
Commonwealth Edison Co.
Duke Power Co.
Florida Power and Light Co.
Georgia Power Co.
Tennessee Valley Authority
Virginia Power

Public Service Commissions

Georgia Public Service Commission
Florida Public Service Commission
Virginia State Corporation Commission

Nuclear Industry Professional Organizations

American Nuclear Energy Council
Edison Electric Institute
Electric Power Research Institute
Institute of Nuclear Power Operations
Nuclear Management and Resources Council
National Association of Regulatory Utility Commissioners

Others

Bechtel Group, Inc.
Combustion Engineering Inc.
Komanoff Energy Associates
National Audubon Society
Union of Concerned Scientists

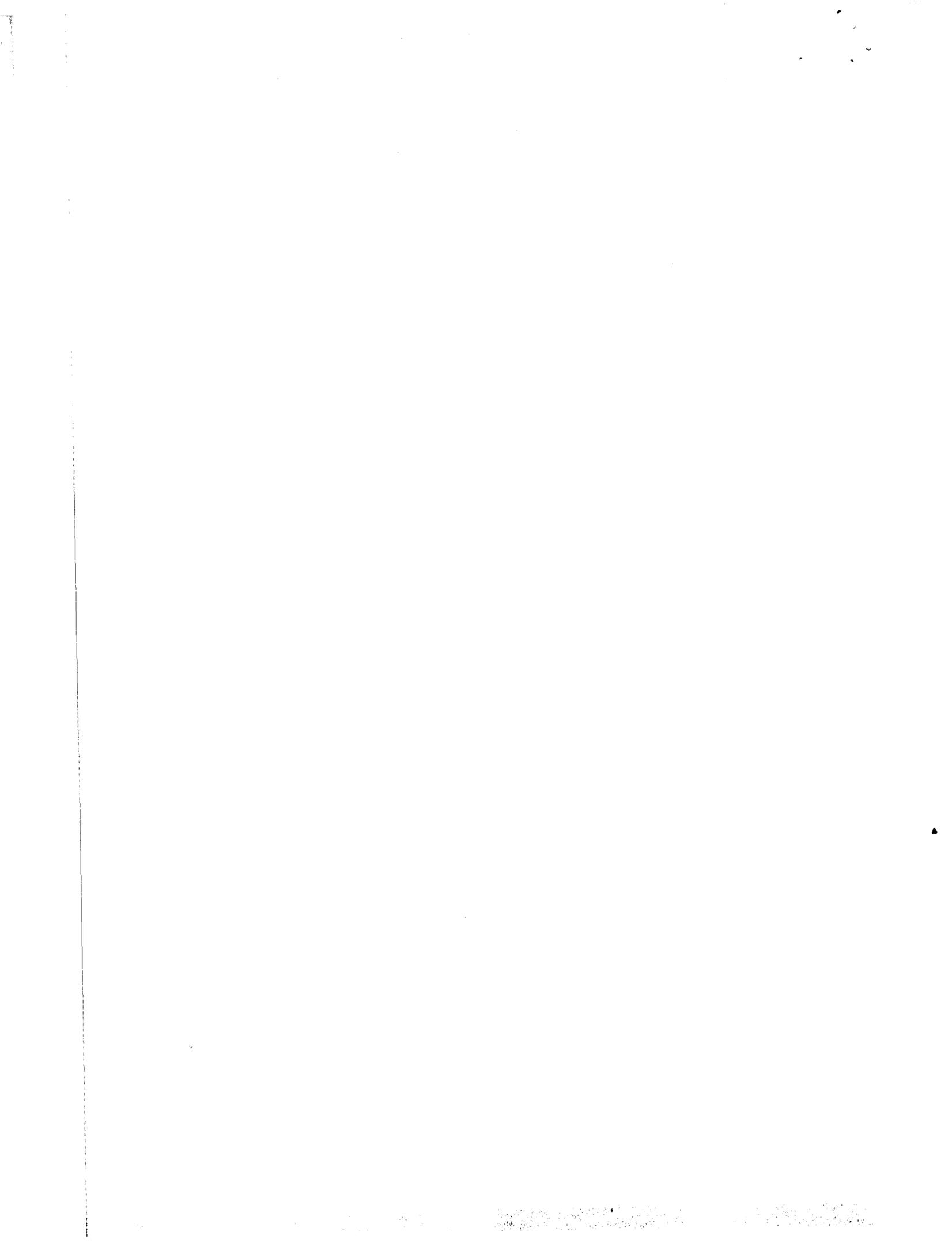
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