BACKGROUND PAPER

Delays in Nuclear Reactor Licensing and Construction: The Possibilities for Reform

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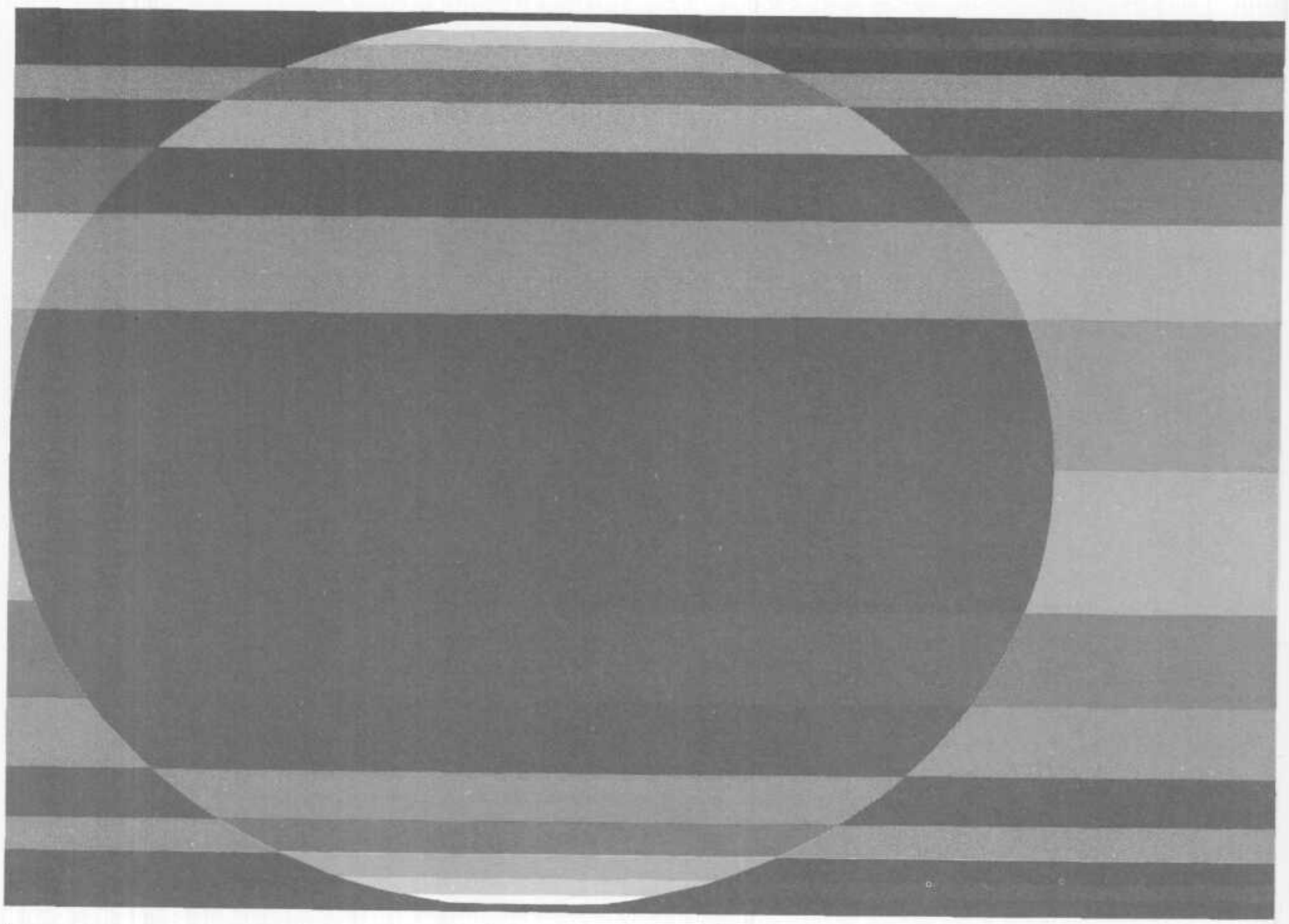

Congress of the United States
Congressional Budget Office

DELAYS IN NUCLEAR REACTOR LICENSING AND CONSTRUCTION: THE POSSIBILITIES FOR REFORM

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PREFACE

During the past decade, the lead times required to plan, license, and build a commercial nuclear power plant have increased from 6 or 7 years to 10 or 11. This added lead time creates costs for the consumer, and places nuclear power at a disadvantage when compared to alternative forms of electrical generation. To help correct this situation, the Administration introduced the Nuclear Siting and Licensing Act in March 1978, and will reintroduce it in the 96th Congress. This report analyzes recent delays in reactor licensing and construction and examines the potential for legislative reform of the reactor licensing and construction process.

Delays in Nuclear Reactor Licensing and Construction; The Possibilities of Reform was written by Everett M. Ehrlich of CBO's Natural Resources and Commerce Division, under the general direction of Richard D. Morgenstern and Raymond C. Scheppach. Marion F. Houstoun edited the manuscript, which was typed for publication by Misi Lenci. Sarah Beth Lambert provided research assistance. The report was prepared at the request of the Energy and Environment Subcommittee of the House Committee on Interior and Insular Affairs. In accordance with CBO's mandate to provide objective and nonpartisan analysis, this paper contains no recommendations.

Alice M. Rivlin
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SUMMARY

Nuclear reactors, developed for commercial purposes in the 1950s, are used by utilities to generate electrical power. A decade ago, the planning, siting, licensing, and construction of a nuclear reactor took 6 to 7 years; today, that process takes 10 to 11 years.

Longer lead times for reactors present two problems. First, increased time leads to higher reactor costs,which result in higher electricity rates for consumers. Secondly, high reactor costs subject nuclear power to a disadvantage when compared with the cost of alternative sources of energy. CBO estimates that the cost of a month's delay in the licensing phase of a reactor—which dates from acceptance of a utility's construction permit application by the Nuclear Regulatory Commission (NRC) to its issuance of that permit—is $8.9 million. A month's delay in the construction phase of reactor--which begins after NRC issuance of a construction permit—is estimated to add $10.6 million to its final cost. An 18-month delay in total reactor lead time can add about 7 percent to the ultimate cost of nuclear-generated electricity.

Although expediting the licensing and construction of nuclear reactors would reduce costs, it might do so at the expense of compromises regarding the levels of safety and environmental protection. This issue—determination of the appropriate balance between the economic and social costs of nuclear energy—is an especially timely one, since the NRC withdrawal of its support of the Reactor Safety Study (Rasmussen Report). This report, accepted by the NRC in 1974 but then repudiated in January 1979, provided the NRC with estimates of the probability of nuclear accidents. Now that its conclusions are no longer judged valid, the chances of a potentially catastophic reactor accident must once more be regarded as "uncertain." It is therefore unclear if current safety and environmental standards should be relaxed until this uncertainty is resolved.

In order to assist the Congress in evaluating the series of licensing reforms proposed by the Nuclear Siting and Licensing Act (NSLA), which was introduced for the Administration in 1978 and will be reintroduced in the 96th Congress, CBO conducted an analysis of recent delays in reactor licensing and construction. This report assesses the degree to which delays in reactor lead time can be ascribed to actions in the public sector and hence ameliorated through legislative reform, estimates the impact of the

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NSLA on reactor lead times, and discusses two other approaches to licensing reform.

The Source of Recent Delays in Licensing and Construction of Nuclear Reactors

CBO's analysis suggests that any legislation redirecting the federal licensing effort will have only a moderate effect in expediting the licensing and construction of nuclear reactors. About two-thirds of all delays—defined for the purposes of the analysis as the difference between actual and targeted dates for licensing and construction—in reactor lead time would be insensitive to reforms of the regulatory process. Delays attributable to changing NRC regulations, redundant reviews, and public participation in the licensing process could, however, be addressed through legislation. Thus, although two-thirds of all delay in reactor licensing and construction would probably not be affected by legislation, the remaining one-third, which represents a delay in the licensing phase of 12 to 18 months per reactor, is a realistic target for regulatory reform.

More specifically, CBO's analysis of recent delays in reactor lead times found that:

- There are three major sources of delay: economic factors, changing NRC regulations, and public participation in licensing.

- The longest delays occur because of unanticipated declines in the demand for electrical power or difficulty in raising financing for a reactor project. In recent years, both factors have increasingly led utilities to reconsider both proposed nuclear reactors and reactors under construction. Together, these factors resulted, on average, in delays of over a year for the sample used for this study. Most of these delays occur after licensing and are largely related to events outside the jurisdiction of the Nuclear Regulatory Commission. Financial delays appear to be more related to financial problems of electric utilities in general and the "capital shortage" of several years ago than to uncertainties created by the nuclear regulatory process;

- The second greatest source of delay is resolution of NRC radiological safety and environmental issues during the licensing process. The median value of delays caused by these issues is about six months, but it can range from zero to two years;

- The third greatest source of delay is public participation in licensing procedures. Although some public participants have been characterized as "obstructionist," many interventions have been instrumental in publicizing important safety and environmental issues. A number of public interventions occur and achieve resolution informally, hence the impact of public participation is often understated, both in terms of delay costs and safety benefits. On average, reactor projects surveyed for this report experienced delays of about six months as a result of both formal and informal public interventions;

- The sources of more minor delays are state/federal redundancy in license review, management problems in construction, and labor disputes. Taken together, these factors typically account for only a few months delay in reactor lead time, but any one has the potential of causing considerable delay in individual cases.

Analysis of the NSLA Proposals

The Nuclear Siting and Licensing Act proposes the following steps to expedite the licensing process and reduce reactor lead times:

- Standardization of reactor and plant designs, which would allow the NRC to issue reactor vendors, such as General Electric or Westinghouse, a "license to manufacture" pre-approved reactors or reactor parts for a period of five years;

- Early site review, which would allow the NRC to approve, before issuance of a construction permit, proposed reactor sites for a period of 10 years;

- The use of adversary public hearings in the licensing process would be limited, but a pilot program for intervenor funding and public participation in the planning stage of reactor projects would be initiated;

- Mandatory review of individual construction permit applications by the NRC's Advisory Committee on Reactor Safeguards (ACRS) would be eliminated;

- State and federal reviews would be coordinated under NEPA; that is, the NRC would be allowed to delegate environmental reviews, as mandated by the National Environmental Policy Act, to individual states;

- The NRC would be allowed to issue operating licenses together with construction permits, and to issue interim operating licenses before operating license hearings are completed.

The two potentially most effective avenues of reform are standardization of reactor designs and early site review. Both of these reforms address delays resulting from substantive issues of NRC regulation. CBO's analysis indicates that standardization could shorten the NRC safety review by 12 to 18 months, if rigorously implemented and accompanied by equivalent reductions in other concurrent review procedures. If a standardization program is to be effective in reducing lead times, however, it must be implemented fully, avoiding any government-mandated changes in reactors already in place ("backfitting"). Thus, adoption of these legislative reforms implies the view that reactor technology is now mature and its risks are acceptable.

Early site review—a procedure that would precede the safety review of a reactor project and could approve, for a 10-year period, a reactor site that met certain environmental standards—would not shorten the licensing period; instead, it would move the site portion of review to a time when the costs of delay are far lower, thereby allowing the utility and the NRC to concentrate on the reactor design. If early site review were coupled with standardization, the licensing procedure would then consist of matching a preapproved design to the parameters of a preapproved site, which could be accomplished in 12 to 18 months. Early site review could reduce delays by up to a year, but only if accompanied by standardization. The full benefits of standardization and early site review would not, however, be realized until the mid- to late 1980s.

Other proposals in the bill would save less time. Elimination of the now-mandatory review by the ACRS would save two to three months, without compromising safety standards. The bill's provision allowing the NRC to approve and utilize the results of state environmental reviews would somewhat expedite licensing in states with rigorous approval procedures. Any alternative to such a system would involve federal preemption of states' rights to review sites for nuclear plants, which is generally regarded as undesirable.

Two changes are proposed in the granting of an operating license, the NRC document certifying that a reactor has been completed as designed and is safe to begin operation. First, the bill proposes that operating licenses be granted when construction permits are issued (a "one-stop" licensing procedure). The bill also proposes that "interim" operating licenses be granted. The reductions in lead times that would result from these two practices appear to be negligible.

The final area of regulatory reform concerns changes in the role of the public in licensing. The bill proposes the following steps with regard to this controversial matter:

- o Interventions would be limited to issues on which there had been "no prior opportunity" for resolution;

- o Adjudicatory hearings (which include the rights to discovery and cross examination) could be held only if factual differences between the parties were discovered. Other disagreements would be settled in legislative hearings, where the hearing examiner would allow an adjudicatory format if, in his view, a difference of fact emerges;

- o The NRC could give priority to construction permit applications that allowed the public to participate in planning reactor designs; and

- o Limited funding would be granted to intervenors, at the discretion of the hearing officer.

The use of the "no opportunity" rule and the limitation of adjudicatory hearings to matters of "factual difference" would expedite hearings to some extent; however, these savings could fail to materialize if the way in which these rules are applied were challenged and overturned in the courts. Public participation in planning reactor designs could be a useful innovation, because it could resolve contested issues at an early stage, and hence eliminate time-consuming interventions at subsequent stages of the licensing process. Consideration might therefore be given to making that procedure mandatory, and its results binding. Finally, although some anticipate that the availability of funding for intervenors would open the door to frivolous challenges of reactor designs and licensing decisions, the provision for funding would give hearing officers a quid pro quo in return for the cooperation and improved specificity and competence of intervenors in the licensing process. Nevertheless, the net effect of these reforms would be minor, no more than a few months per reactor.

In the last analysis, any reform of the current nuclear reactor siting and licensing process raises questions involving U.S. policy toward nuclear power. Proponents of nuclear power claim that many of the delays that reactors now experience are the product of poorly applied or unneccessarily stringent reactor standards. Although CBO cannot evaluate the technical merit of each NRC standard and regulation, in general, current nuclear reactor regulations conform to a strategy of risk aversion, which reflects continuing uncertainty about the chances of a catastrophic accident. In order to reduce increasing reactor lead times and costs, the Nuclear Siting and Licensing Act would modify this strategy and move towards a view of nuclear reactor technology as more stable and acceptable than previously perceived.

Impact of the NSLA

In sum, the Nuclear Siting and Licensing Act would have only a limited impact on reactor licensing and constructing times, primarily because only a third of all delay in reactor lead times can be ameliorated through legislation. By the early 1980s, the construction permit review period could probably be reduced from a recent average of 30 months to 24 months, with the bulk of the reduction stemming from fewer ACRS reviews, elimination of some state/federal redundancy, and some standardized parts. By the mid- to late 1980s, however, a reduction of as much as 15 months in licensing time could be saved, if early site review were coupled with permanent standardization. Whether or not these reforms will come to pass depends upon how the outcome of still unresolved safety issues affects the acceptability of standarized designs, and whether or not early site review would undermine the integrity of the licensing process by "grandfathering" reactor projects. It is doubtful that changes in the procedures for public participation, "one-stop" licensing, or interim operating licenses would expedite reactor licensing and construction. Full implementation of the bill's provisions would decrease the cost of a nuclear power plant by about 9 percent and the cost of nuclear-generated electricity would be reduced by 7 percent. Further, should the real price of oil rise by 2 percent a year or more in the future, delayed reactors would also mean higher electricity costs, as the oil- and coal-burning units they were to replace are extended beyond their normal life.

Alternative Approaches to Licensing Reform

There are two alternatives to the NSLA: in-house reform of the NRC's licensing procedures and a "full push" policy strategy analogous to procedures used in Europe.

The NRC has extensively reviewed its licensing procedures, in a 1977 report entitled Nuclear Power Plant Licensing: Opportunities for Improvement, This report, known as the "Denton Report," urges greater use of generic rule-making (setting criteria and making judgments applicable to all reactors, as opposed to resolving issues on a case-by-case basis); more standardization (which the NRC and the nuclear industry are promoting now); issuance of more limited work authorizations (which permit utilities to begin certain construction activities before the reactor safety review is completed); and more NRC staff assistance to utilities in order to ensure more adequate construction permit applications. NRC in-house reform would accomplish many of the objectives of the NSLA, without new legislation, and would shorten the licensing period by a year in the late 1980s.

The second alternative to the NSLA is termed a full push approach because it explicitly views nuclear power as a mature and acceptable technology; hence it would eliminate many of the licensing procedures that are now part of the "risk averse" regulatory policy of the NRC. Under the full push approach, licensing would be conducted by the Department of Energy and the concerns of the NRC would be limited to radiological issues. This approach would also call for one-stop licensing, full use of standardization, and elimination of public participation. It might also call for legislation eliminating the currently mandated National Environmental Policy Act (NEPA) review, which would make NRC's calculations of the social costs of the reactor unnecessary. Under a full push approach, licensing could be cut by 18 months and thus conducted in one year, a slightly greater reduction than that effected by the NSLA.

CHAPTER I. INTRODUCTION

Nuclear reactors, first developed for commercial purposes in the 1950s, are used by electrical utilities to generate steam that in turn produces electric power. A decade ago, the planning, siting, licensing, and construction of a reactor took 6 to 7 years. Today, the same process takes 10 to 11 years. This increase in "lead time" increases the utility's costs, which are then passed on to the public in higher electric rates. Higher reactor costs also influence a utility's decision to use nuclear power rather then to depend upon coal to generate electricity.

By proposing a series of licensing reforms, the Nuclear Siting and Licensing Act (NSLA), which was introduced for the Administration in March of 1978 and will be reintroduced in the 96th Congress, has become the focal point of the debate over ways of changing nuclear reactor licensing procedures and reducing the lead time needed to build them.

Although increasing nuclear reactor costs could be cut by expediting reactor licensing and construction lead time, that strategy might increase their social costs, in terms of safety, environmental protection, and the affected public's right to participate in the licensing process. Each of those costs must be balanced against the desire to license and build nuclear reactors as economically as possible.

The Congress' decision as to how to weigh the trade-off between expediting reactor lead times and minimizing the social costs of doing so will be based on an implicit judgment as to whether or not nuclear reactor technology, and the accompanying technologies for waste disposal or reprocessing, are "mature" and "acceptable"--that is, predictable and as safe as other activities occurring in the course of daily events.

These potential social costs are now the subject of attention because the Nuclear Regulatory Commission (NRC) has withdrawn its support of the Rasmussen Report, 1/ which it had used to calculate the probabilities of serious nuclear accidents. In the absence of this report, the probability of a major accident, a large component of social costs, must now be viewed as uncertain.

1/ U.S. Atomic Energy Commission, Reactor Safety Study, 1975.

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This paper analyzes the reasons for recent delays in reactor lead times and discusses the advantages (in terms of reduced lead times and hence lower reactor costs) and the disadvantages (in terms of possible safety compromises or poor regulatory decisions) of reforms put forward in the NSLA. Chapter II first briefly describes the development of the U.S. nuclear industry and current nuclear policy, and then presents in more detail current federal licensing procedures regulating the construction of nuclear reactors. Chapter III presents the methodology, and Chapter IV, the results, of an analysis of delays in reactor lead times. The relative importance of different kinds of delays are also assessed. Chapter V analyzes the major components of the NSLA and assesses the costs and benefits of their implementation. Chapter VI discusses alternative approaches to the issue of licensing reform: one approach would require no new statutory authority for the Nuclear Regulatory Commission the second is a "full push" approach, reflecting procedures now used in Europe.

CHAPTER II. CURRENT NUCLEAR POLICY AND REACTOR LICENSING AND CONSTRUCTION

As of November 30, 1978, 70 nuclear reactors were operating in the United States, and, 90 were under construction (including 32 undergoing final regulatory review before commercial operation). In addition, 34 reactors were undergoing construction permit reviews (including 4 with authorizations to do basic site preparatory work); 9 had been ordered but had not yet formally applied for a construction permit; and utilities had announced plans to build 8 more. Despite these developments, the nuclear industry now finds itself at a critical juncture: reactor orders have been slowing and, in the eyes of reactor vendors, the licensing procedures now regulating the construction of nuclear power plants has been a major contributor to that decline. This chapter describes both the historical development and the current regulatory process of the nuclear power industry.

CHANGES IN THE NUCLEAR INDUSTRY AND IN FEDERAL NUCLEAR POLICY

During the past 20 years, the nuclear industry has undergone an expansion and decline aptly described by one observer as from "rags to riches to rags." In the 1950s, the Atoms for Peace program and the newly formed Atomic Energy Commission (AEC) promoted the industry in an effort to develop nuclear energy as a cheap source of electrical generation. Thus, during this early period, private utilities received government subsidies for nuclear power research and commercial demonstration. In the early and middle 1960s, private firms (notably General Electric and Westinghouse) began providing nuclear reactors to utilities on a "turnkey" or fixed-price basis. In order to promote their product and to learn more efficient techniques of construction and design, these suppliers (or vendors) incurred substantial losses, in part because they underestimated the costs of reactor construction and did not anticipate the entry of competing firms into the nuclear energy market. By 1967, over 30 reactors a year were being ordered, and 1,000 megawatts of generating capacity were already in place. Although orders slipped in the late 1960s and in 1970, probably as a result of macroeconomic trends, a level of 30 reactor orders a year was reached again during the 1972-1974 period. In the past several years, however, the nuclear industry has experienced a sudden turnaround, with cancellations of old reactor orders exceeding new orders in 1975 and 1976.

Why has the growth of nuclear power slowed so dramatically? First of all, nuclear power has never fulfilled the initial vision that it would be "too cheap to meter." The cost of nuclear power has steadily risen, for a variety of reasons. Capital construction costs have risen, both because the size of reactors has grown and because the nuclear regulatory process has increased the complexity of their design. Fuel prices have also risen, as a result of the introduction of OPEC prices into the energy market, the scarcity of uranium fuel, and the alleged operations of a uranium fuel cartel. Thus, although nuclear power was hailed as a potentially cheap source of energy, in many parts of the country it is now roughly equivalent in kilowatt cost to coal.

The development of nuclear power has also been obstructed by the problems that regulated utilities generally have in raising capital. In the 1960s, when energy prices were stable and the demand for electricity grew at a predictable and sizable rate, utilities were considered a good investment. But changing conditions in the early 1970s gave rise to a continual escalation of utilities' costs, which, when coupled with a lag in the recalculation of their rates by public utilities commissions, created a profit squeeze that made utilities a less desirable investment. Although their financial outlook is more optimistic today than it was several years ago, it is still clouded by uncertainty in projections of electricity demand, uncertainty regarding future changes in NRC standards, and continuing questions concerning the desirability of the commercial use of nuclear power.

In recent years, concern over the safety and environmental effects of commercial nuclear reactors have led a growing number of community and environmental groups to challenge nuclear plant construction and operating plants in court and in regulatory proceedings. This, in turn, has made the growth of nuclear power a political issue. Today, few public officials fully endorse nuclear energy.

Thus, while national policy in the 1950s and 1960s seemed oriented toward expansion of nuclear power, nuclear policy today has become ad hoc and amorphous. On the one hand, the government's caution regarding nuclear power is reflected by the NRC's use of stringent and continually evolving safety standards for nuclear plants. These standards, which may be best described as "as safe as practicable," reflect the NRC's essentially risk-averse approach to nuclear reactor construction. On the other hand, however, the use of nuclear energy is viewed by some as inevitable, and the government continues to assist the development of nuclear energy through its funding of waste disposal site exploration, waste disposal technology, safety research, and fuel reprocessing. At present, then, national policy both endorses nuclear power and uses risk-averse licensing procedures that inhibit its rapid development. Resolution of these conflicting trends is now complicated by the NRC's recent withdrawal of support for the "Rasmussen Report," upon which it had relied for estimates of the probabilities of serious nuclear accidents.

THE NRC CRITICAL PATH

The two major phases of reactor lead time are licensing and construction. Together, they constitute what the NRC has defined as a reactor's "critical path"--that is, the landmark federal licensing and private-sector construction activities that lead to its commercial operation (see Figure 1).

Initial Planning

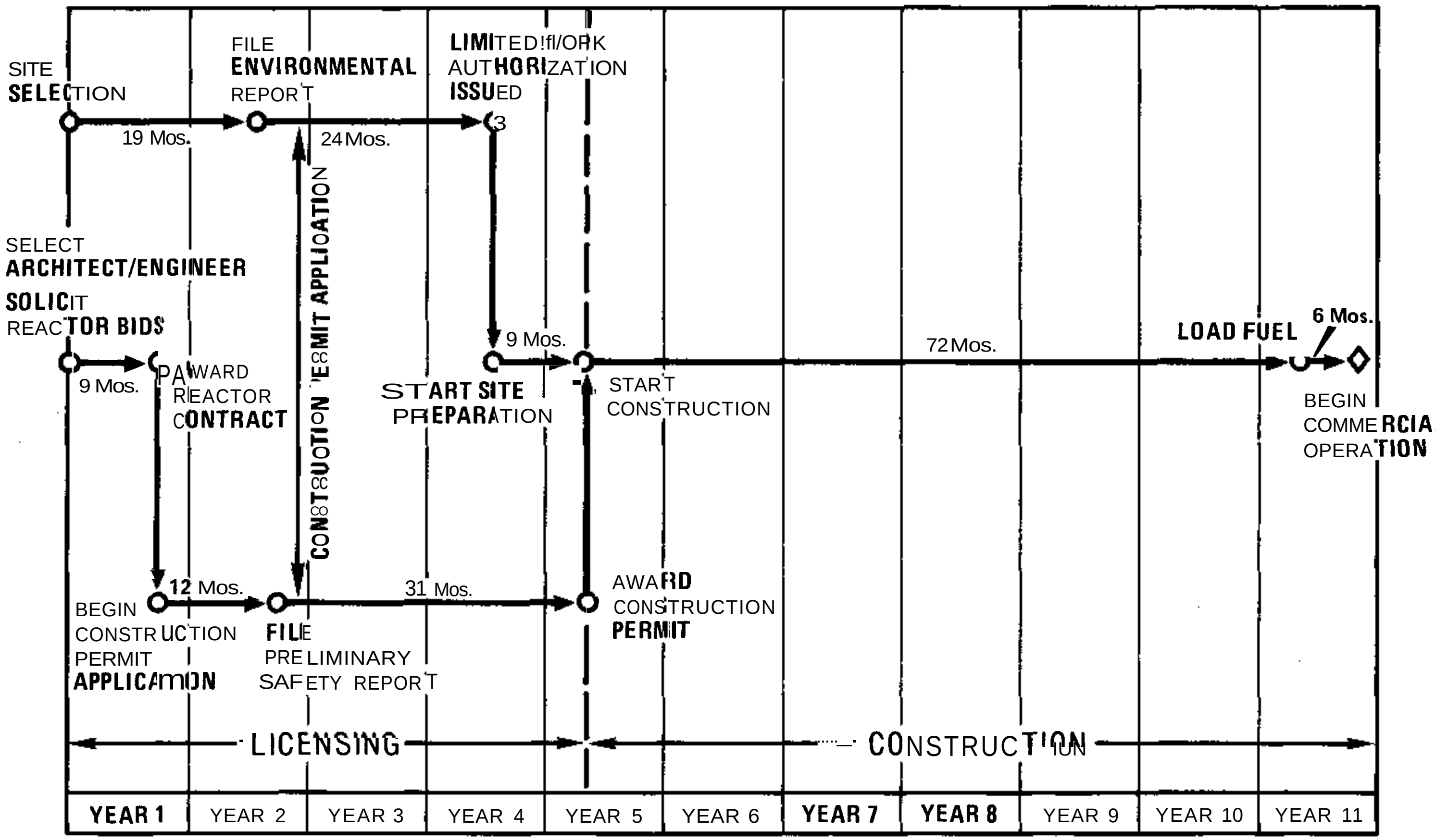
A utility considering building a nuclear reactor to help meet future demands for electric power usually contracts with an architect/engineering firm specializing in the area (leading firms include Bechtel, Sargent and Lundy, and Stone and Webster) for estimates of the cost and potential power of a reactor. (Some utilities have, however, integrated this function into their operation.) If the utility decides to construct a nuclear reactor, the actual working reactor--the nuclear steam supply system (NSSS)—will be supplied by one of several firms: Babcock and Wilcox, Combustion Engineering, General Electric, or Westinghouse. Construction of the balance of the reactor—the "balance of plant," which includes containment and control systems as well as the actual edifice in which the reactor is housed--will be supervised by the architect/engineering firm, by the utility, or sometimes by a third firm. Selection of a reactor vendor, and perhaps of a firm to construct the balance of the plant, as well as selection of a site for the reactor, are thus key events occurring in the planning stage of a reactor project. Preparation of the utility's application to the NRC for a construction permit also takes place during this initial phase.

The Licensing Phase

The mandate of the NRC is to protect the health and welfare of the public by setting standards for nuclear reactor safety. Once initial plans for a reactor are completed, the utility applies for a construction permit from this commission. The application, which must include a preliminary safety analysis report, an environmental report, and anti-trust information, first undergoes an NRC acceptance review, to determine whether it contains all necessary information. Accepted applications are then docketed. The NRC

Figure 1.

Critical Path and Average Lead Time of the Licensing and Construction of a Nuclear Reactor, 1978.



SOURCE: Derived from *Licensing, Design, and Construction Problems: Priorities for Solution,* Atomic Industrial Forum, January 1978.

staff next reviews the preliminary safety analysis report submitted by the utility. This review requires two rounds of questions by NRC staff, who generally ask several hundred questions. The NRC then issues its own safety evaluation report, which is forwarded to the Advisory Committee on Reactor Safeguards, an independent board of 15 nuclear experts, which holds public meetings and reviews the report. 1/ The outcome of these activities is an official letter to NRC with the committee's view of the potential safety of the reactor.

A similar review process simultaneously occurs regarding environmental issues. The **utility's** environmental report consists of data on the environmental impact of the proposed reactor. On the basis of that report and subsequent rounds of questioning, the NRC staff prepares a draft environmental statement, which is reviewed by the Council on Environmental Quality. A proposed reactor must also satisfy the Environmental Protection Agency (EPA) that its discharges will meet water quality standards set by the 1972 amendments to the Water Pollution Control Act.

The NRC also evaluates both the utility's "need for power" (by projecting its future reserve margins if the reactor is not built) and its financial ability to finish the project (its access to financing). In addition, the Attorney General must rule as to whether or not the construction of the reactor would violate anti-trust statutes.

Public hearings concerning a reactor construction permit are held before the three-member Atomic Safety and Licensing Board (ASLB). The purpose of these hearings is to bring the community in which the reactor will be built into the decision-making process, both to protect their interest and allay their concerns. ASLB hearings are advertised in both the Federal Register and in local newspapers of the affected community. Members of the public who wish to testify or present statements may participate in the hearings as interested parties or **"intervenors."** These hearings can have one of several results. The ASLB can decide that the plant may be built and issue a construction permit; it can decide against the plant and refuse to

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1/ NRC staff supplements to the safety evaluation report are also reviewed by the Advisory Committee. These supplements are not an uncommon occurence, owing to the practice of expediting NRC issuance of these reports by allowing items requiring more time-consuming analysis, such as radiological effects, to follow the balance of the report and the Advisory Committee on Reactor Safeguards' conclusions. It should also be noted that only 30 to 35 percent of a reactor has been designed when it is reviewed for construction permit issuance; the rest is designed and approved during construction itself.

grant a construction permit; or, at the request of the utility, it can review only environmental matters, and issue a limited work authorization, which permits the utility to begin preparatory work at the construction site, but not construction of the actual reactor. A utility with limited work authorization must, however, go back to the NRC to complete its safety review so that the reactor can be built. Objections to ASLB decisions are heard by the Atomic Licensing Appeal Board. Once the board reaches a decision, it can only be overturned by the NRC Commissioners, who oversee the process, or through judicial review.

Satisfying the NRC licensing requirements does not necessarily mean that a reactor can be constructed. States are empowered to conduct all aspects of review, except for radiological emissions, an area pre-empted by the Supreme Court. Therefore, situations can arise in which the NRC has completed its review, but state approval has not yet been issued.

The Construction Permit

The issuance of a construction permit ends the first, or "licensing," phase of a reactor's critical path. The second phase consists of the actual construction of the reactor. One-third of the way into the construction period, the reactor pressure vessel--the actual steam vessel in the reactor--is set into its mounts. The construction of the basic housing of the reactor has usually been completed by this point. Once the pressure vessel has been set,its control system, its plumbing connection, and the reactor containment (the concrete shield that encloses the entire reactor) can be built around it. As construction of a nuclear plant nears completion, however, the utility must apply to the NRC for an operating license, which certifies that the reactor has been built in accordance to plan and is safe to operate. The application for an operating license is accompanied by the utility's final safety analysis report, which covers all safety issues in detail, and an environmental report. Any safety or design changes in the reactor must also be discussed by the utility. The ASLB grants operating licenses in the same manner as it grants construction permits. An operating license hearing may be held by the licensing board, if requested by an interested party.

Once granted an operating license, the utility loads the first fuel into the reactor, and the reactor's first "criticality" is experienced. This "fuel loading date" is the targeted completion of construction. After about six months of initial testing, the reactor is brought into commercial operation.

CHAPTER III. A METHODOLOGY FOR ANALYZING DELAYS IN REACTOR LEAD TIMES

Congress is now considering legislation aimed at shortening the increasing lead times of nuclear reactors. In order to reform the reactor licensing and construction process effectively, however, the reasons for its elongation must be determined. This chapter develops a methodology for analyzing increased lead times. Results of the ensuing analysis are presented in the following chapter.

GENERAL METHODOLOGY

Although studies have been conducted to document increased reactor lead times, they have focused solely on determining recent trends in licensing and construction times. This analysis, however, attempts to determine the extent to which the increase in lead times--defined here as the difference between targeted and actual times for licensing and construction--can be ascribed to factors or events that originate in the public sector, and hence can be affected by legislative reform.

Like any other product, a reactor is the result of a production process that requires a stream of inputs. When one or more inputs is not available, a production process becomes bottlenecked. Generally speaking, these inputs can be categorized as labor, materials, management, and financing. In the case of reactors, government approval through a licensing process must be added to the list of inputs, for without it, construction cannot proceed. The unavailability of government approval, like the unavailability of any other input, can become a constraint on production, resulting in delays. The list of inputs therefore becomes a list of possible "constraints" on reactor production. Thus, one can determine the origin of reactor delays by observing which input into reactor production is unavailable when it is needed.

This analysis measures the delays in the licensing and construction of reactors that have been recently reviewed by the NRC and classifies them according to a typology of delays based on the list of inputs into reactor construction. The extent to which reform of the reactor regulatory process can expedite lead times can then be estimated by determining the extent to which delays in current reactor lead times originate with public sector

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actions. Similarly, the types of regulatory reform that are most likely to be effective can be estimated by observing the kinds of public sector actions involved.

The usual two-part division of reactor lead time into licensing (the period of time between a utility's application for and NRC issuance of a construction permit) and construction (the period between the issuance of a construction permit and reactor start-up) is helpful because of differences in the relative importance of the different inputs. During licensing, the most important input is usually public sector action. Labor and materials input availability problems, on the other hand, are generally not experienced until after a construction permit has been issued by the NRC, because actual construction cannot take place until then.

THE LICENSING AND CONSTRUCTION PHASE SAMPLES

In order to classify recent delays, data that provide case-by-case histories of reactor licensing and construction must be found. Such records are maintained by the NRC. A 1977 NRC document entitled Reactor Licensing Schedule Performance Critique provides the licensing history of 24 reactor projects—some involving 2 or 3 reactors, which were usually licensed as a group--that received construction permits between July 1, 1974 and December 31, 1977. Hence, this document allows observation of reactor licensing times that exceeded their NRC-determined target dates, and determination of their duration and source.

Construction completion target dates are set by the utilities themselves. When a utility receives a construction permit, it announces a fuel loading date, based on its own estimation of how long it will take to build the reactor in question. For the purposes of this analysis, it is assumed that the utility's announced fuel loading date represents the minimum feasible time necessary to complete construction. Any revision of this target to a later data therefore constitutes an observable delay or slippage in the construction process. Thus, once construction begins, with either a construction permit or a limited work authorization, delays can be determined by announcements of slippages in a reactor's fuel loading date, which is reported in the NRC's monthly Construction Status Report.

As of August 1977, 91 proposed reactors had been issued construction permits according to that report. Five of those reactors had not yet scheduled any construction (and hence could not have had any delays), and two had cancelled their projects and therefore their construction permits. Hence, the sample used in this report to determine the amount and causes of delay in the construction phase comprises 84 reactors.

Although the data in both the NRC Critique and the Construction Status Report have been the subject of varying interpretations by the NRC and the nuclear industry, this analysis relies upon neither's interpretation of any data. Delays reported in the Construction Status Report are only briefly described, and when the information provided was judged insufficient to classify a delay, phone calls were made to the utility or to NRC to obtain additional information. The validity of the classifying judgments made for this analysis was also checked through follow-up calls to utility representatives of two subsamples of reactor projects randomly drawn from the licensing and construction phase samples.

A TYPOLOGY OF DELAYS

This section describes the types of delays that may occur in the licensing and construction of nuclear reactors.

Types of Public Sector Delays

Constraints on the licensing and construction of nuclear reactors originating in the public sector can be classified along the following lines:

- Delays that occur because of changing regulations, or because the applicant and the NRC differ over how to bring a proposed reactor into conformity with regulatory standards;
- Delays occurring because of redundancy or inefficiency in the government's transaction of its regulatory responsibilities;
- Delays occurring because public participation requires the expenditure of additional time on the part of the NRC staff and ASLB hearing officers, often in hearings.

These three types of public sector delays, described in more detail below, occur primarily during the licensing phase. They can, however, also occur during construction if part of the NRC's review of a reactor component is designed after construction permit issuance, or if new information forces a reconsideration of a previously approved design.

Substantive Issues. NRC safety and environmental standards have evolved internally, as a result of experience, and the reactor licensing process has also had to confront new issues. This has created what is termed "moving standards" for reactor regulations; that is, reactor plans that were acceptable in the past may not be acceptable now or in the future.

NRC design standards have changed as each reactor brings with it new lessons in design. An example of this increasing sophistication is the new level of detail afforded reactor fire safety standards after a fire at the Browns Ferry nuclear generating plant. Critics of the NRC, however, claim that increased detail and attention in NRC reviews is more a product of bureaucratic growth than a response to past lessons in reactor safety. They argue that the NRC has become too involved in changing reactor design plans that have already been approved (a process known as "ratcheting" a design) or in mandating changes in reactors that have been built or are under construction ("retrofitting" or "backfitting"). NRC policy approves such changes as part of its mandate of ensuring that all reactors operate at the greatest level of safety currently deemed practicable; nevertheless, in order to prohibit trivial design changes, the NRC employs a standard requiring that each backfitted design change bring about "substantial additional protection." NRC reactor design standards can thus change over time. Fire safety regulations and the requirement that every reactor have an emergency core cooling system (ECCS) are examples of such changes. In the mid-1960s, all existing plants were retrofitted with ECCS. The Indian Point plant, however, opted to close rather than implement the mandated changes. Implementation of new fire safety rules resulting from the Browns Ferry incident will cost approximately $1 million per reactor.

The scope of NRC has also broadened in recent years. The foremost instance of an externally induced expansion of NRC issues is the inclusion of cost-benefit calculations in reactor licensing, following the 1971 Calvert Cliffs Coordinating Committee Inc. v. AEC reactor decision. This court interpretation of the National Environmental Policy Act (NEPA) mandated the NRC to weigh, on a cost-benefit basis, every proposed plant against a group of theoretical alternatives that use different fuels at different sites. Increasing sensitivity surrounding the issue of nuclear power has similarly compelled the NRC to broaden its efforts concerning seismic effects, population proximity, and land use. The growing size of reactors, as well as their increasing sophistication, have also generated more complex safety and related issues. Reactors completed in 1970 had an average rating of 604 megawatts; those of 1976 vintage, a rating of 901 megawatts; and reactors due to be completed in 1983 will measure 1,105 megawatts.

Redundancy and Inefficiency. Redundancy in the licensing procedure, or poor coordination between the different governmental entities with regulatory responsibilities, can occur. States and muncipalities have the legal right to examine issues included in the NRC review, particularly in the areas of environmental impact and the need for a nuclear reactor. Hence, utilities must sometimes provide—sequentially—the same material to a state government, the NRC, and the EPA. 1/ Some states, notably New York, Maryland, and Wisconsin, have more stringent and more time-consuming environmental and demographic considerations than the NRC or the EPA. Moreover, based on the same evidence, states may reach a different judgment than the NRC, as was the case in the Seabrook project.

Redundancy between state and federal reviews is only the most serious aspect of the general problem posed by having different federal and state agencies conducting or participating in the licensing process. Licenses can be held up if any one agency fails to provide data for another's review in a timely fashion. Reactors at the Palo Verde and Skagit sites, for example, were delayed during their construction permit review because of NRC difficulty in obtaining final reports from the U.S. Geologic Survey.

Public Participation. A license can be delayed as a result of contested hearings or public "interventions"; however, most of these delays are for short periods of time. Public participation has always been a goal of NRC, and its predecessor, the Atomic Energy Commission, traditionally sought to educate the public regarding nuclear power through public hearings. But nuclear vendors contend that the opportunity to intervene in licensing procedures is currently being used to force major safety or environmental changes in proposed reactors. And, in fact, interventions have grown in subject matter as well as in number. Today, they include critiques of national energy policy or discussion of the economic or technical problems of nuclear power as well as site- and reactor-specific issues. Hesitancy on the part of NRC hearings examiners to limit the subject matter of interventions is often explained by the possibility that the results of these hearings will be overturned in court.

Types of Private Sector Delays

With the exception of constraints originating in the regulatory role of the public sector, it is assumed that a reactor can be delayed only if there is a problem related to some input into the production process: labor, materials, financing, or management. A description of how such delays, which typically—but not invariably—occur after construction permit issuance, develop is presented below.

1/ See, for example, "Nuclear Power Plant Delays in New England" (prepared by New England Federal Regional Council Energy Resource Development Task Force Bulk Power Committee, Federal Energy Administration, November 1976).

Labor. Reactor construction requires highly trained and specialized workers, who may be in scarce supply and whose skill level increases their bargaining power. Reactor projects have thus been subjected to strikes, as occurred in the Ano, Diablo Canyon, and North Anna projects. Other projects have reported poor labor productivity or shortages of skilled workers.

Materials. Problems sometimes arise because of the poor quality or the unavailability of materials or components. These problems are not necessarily generated by the specialized nature of reactor parts and components; for example, at the Diablo Canyon project, portions of the low-pressure turbine were delivered in unsatisfactory condition and required reblading before they were installed. Delays of this type are attributable to the vendor. Similarly, both the Zimmer and Watts Bar projects were delayed by the unavailability of parts, such as bolts and rods. Like labor delays, these typically occur during construction.

Financing. Utilities usually borrow large portions of their capital needs in the money markets: aside from the traditional bias toward debt financing found in the tax laws, regulated utilities theoretically cannot use pricing techniques to adjust revenues to generate funds internally. Equity funding is rarely employed. Moreover, borrowing entails a capital cost that usually may not be incorporated into the rate base, although some states will allow rate base calculations to include construction work in progress. Finally, given the current conventional planning size of reactors (about 1,100 megawatts), the cost of a reactor is prohibitive without outside funds—generally over $1.2 billion. Nor is borrowing easy, especially since investor confidence in utility nuclear securities was dampened by Consolidated Edison's failure to pay a quarterly dividend in 1974. Many investors are wary of such projects. In their report of September 1976, Jesups and Lamont, a New York brokerage house, urged caution in the purchase of nuclear securities because of waste storage, reprocessing, and safety considerations.

This financing problem has expressed itself in a wave of reactor delays, the great bulk of which occurred in late 1974. In September through November of that year, at least 19 reactors at 11 different sites were delayed because of financial consideration. Financial obstacles have also been linked to slackening demand for electric power, because decreased electric power demands may make it impossible to justify a reactor's cost, as in the Limerick and Sumner projects. This differs from the problem of tight capital markets, as occurred in the cyclical "capital shortage" of 1974-1975, which delayed the Catawba and McGuire projects. One possible recourse for a utility in a strapped financial position is an appeal to the relevant state public utility commission; such assistance may, however, not be forthcoming, as was the experience of the River Bend station before the Louisiana Commission. Delays of this type can occur during licensing or construction.

Management. Management delays can be classified as project or demand delays. Project management delays occur within the framework of a decision to build a nuclear plant, during its construction. These delays are related to unanticipated problems in the design or performance of reactor parts, or to incorrect estimates of the construction schedule 2/ Similarly, some utilities find that they must redesign components during construction. 3/ Delays of this kind must, of course, be distinguished from government-ordered design changes, as experienced at the Fermi project.

Project management delays also stem from the "doctor-patient" relationship between either the architect/engineering firm or the reactor manufacturers and the utility. Although some utilities are now doing their own designing and engineering, many depend on a contractor for answers to technical interrogatories by the NRC staff. This slows down the licensing process. ERDA's Robert D. Thorne has noted that ". . . the utilities have to deal with the NRC, not just use the builders as their technical arm. They've got to show that they know what they're talking about. Until that happens they will stay in a rather laborious regulatory process." 4/

Demand delays relate to a utility's decision to build the plant itself and occur during both licensing and construction. A frequent source of delay is changes in a utility's estimates of its "need for power." On the basis of historical price and behavior trends, many reactors, either now under construction or being planned, were thought necessary to meet future demands for electrical power. These trends have now been altered by the introduction of OPEC price levels into the energy market, leading to demand cutbacks. When estimates for power are revised, a utility will frequently delay its fuel loading date. Thus, reactor delays can occur because of broad changes in national and international economies, such as

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2/ Late delivery of equipment, for example, held up projects at Hatch, MacGuire, and Sequoyah.

3/ This was the case when the containment ice condensors at the Cook project had to be redesigned by Westinghouse.

4/ Speaking to the Atomic Industrial Forum's Conference on Nuclear Power Financial Consideration (July 1977).

higher energy prices or higher interest rates. Such reestimations of the demand for electrical power have occurred regularly during the past four years. 5/

CAVEATS CONCERNING THIS APPROACH

Analyzing reactor delays poses a number of methodological problems. Assigning an observed delay to a specific cause often requires making assumptions about the motives of the actors involved--both the NRC and the applicant utility. For example, a delay of several months may occur during the NRC staff's preparation of its final safety evaluation report because the staff and the utility cannot agree on certain safety considerations. Ascribing such a delay to "prolonged safety evaluation" requires an assumption that the utility sought to minimize this expenditure of time. In fact, however, the utility could consider such a delay as inconsequential; for example, it might be aware of a concurrent separate review or an environmental proceeding conducted by a state government, or a financing problem, which would hold up issuance of a construction permit even if the safety concerns were resolved.

Similarly, the NRC could be taken off the "critical path" towards licensing if the utility is taken to court by a state environmental agency. The NRC would then find that it had extra time to conduct its review while litigation was underway, and it would not be responsible for the resulting delays in licensing. For example, in the licensing of Waterford Unit 3, NRC has contended that an unresolved anti-trust issue led the utility to extend the safety review process, in the hope that more favorable terms could be reached with the NRC while the anti-trust issue was being litigated. In the case of Catawba Units 1 and 2, the utility was forced to postpone the plant because of financial difficulties; had it not done so, the NRC review of its emergency core cooling system design would have produced delays.

Delays can also be interrelated. Financial delays, for example, may be to some extent related to regulatory uncertainty. Similarly, materials delays could be a product of the instability of design criteria produced by regulation.

5/ The most notable delay of this type could be those associated with the Harris project, a group of four reactors delayed an average of 54 months because of revised energy demand projects. Load reconsiderations have also played a role in delaying reactors at Catawba, Limerick, and Susquehanna.

Uncertainties regarding ascriptions of delay were resolved to the maximum extent possible in the analysis, using CBO's judgment. When necessary, the relevant utility spokesperson and NRC staff member were contacted to obtain enough detail regarding a particular event to make a reliable judgment concerning the source of a delay.

CHAPTER IV. RECENT DELAYS IN NUCLEAR REACTOR LICENSING AND CONSTRUCTION

The licensing and construction process described in Chapter n now requires approximately 10 years to complete (see Figure 1). To this must be added at least one year for initial planning by the utility, devoted to selecting a site, awarding a contract for the reactor vessel, and preparing the construction permit application.

More precisely, during this decade, construction permit reviews by the NRC have generally taken about three years, as compared with the one- to two-year licensing period common in the last decade (see Table 1). The NRC target for construction permit issuance is now about 20 months. Similarly, the average construction lead time for reactors completed in the early 1970s was approximately five years; reactors slated for completion in the next several years will take about seven and one-half years to build.

Given the significant economic costs of increasing lead times, this chapter seeks to analyze the source of recent delays in both the licensing and construction phases of reactors, and to estimate their cost. Using the methodology described in Chapter III, the relative importance of different delay-causing factors are also assessed.

DELAYS IN THE LICENSING PHASE OF REACTORS

The 24 reactor projects in the licensing sample analyzed in this report experienced an average of 10 months delay beyond the 21-month target period established by the NRC. Unfortunately, several delay-causing factors may occur simultaneously, and the available data are not detailed enough to permit derivation of the distribution of the total amount of delay among them.

The sources of delay in the licensing of these reactor projects can, however, be determined (see Table 2). Most delays were the result of difficulties in the technical resolution of safety and site-specific environmental standards. These delays occur when the NRC staff questions the claims or conclusions of the utility's preliminary safety report analysis or its environmental report. More specifically, two issues dominated delays in the NRC safety review: questions concerning the reactor design regulations

TABLE 1. AVERAGE REACTOR LICENSING AND TOTAL LEAD TIMES, 1956-1977

Calendar Year	Number of Construction Permits Issued	Average Megawatts	Average Construction Permit Review Time a/ (in months)	Number of Reactors Completed as of 10/77	Average Total Lead Time b/ (in months)
1956	3	175	12	3	78
1957	1	175	16	1	49
1958	—	—	—	—	—
1859	1	22	9	1	44
1960	7	45	12	7	48
1961	—	—	—	—	—
1962	1	40	19	1	68
1963	1	50	5	1	57
1964	3	552	10	3	53
1965	1	610	14	1	54
1966	5	722	7	5	62
1967	14	764	10	14	70
1968	23	814	14	21	82
1969	7	910	18	5	55
1970	14	764	20	14	72
1971	4	963	21	3	93
1972	14	815	35	—	—
1973	14	1,076	34	—	—
1974	9	1,069	31	—	—
1975	9	1,166	26	—	—
1976	9	1,136	25	—	—
1977	11	1,120	39	—	—

SOURCE: Department of Energy, U.S. Central Station Nuclear Electric Generating Units; Significant Milestones, March 1978.

a/ As measured from date of construction permit application to date of construction permit issuance, a period which constitutes the licensing phase of a reactor.

b/ As measured from date of construction permit application to date of initial fuel loading.

TABLE 2. SOURCE OF DELAYS IN THE LICENSING PHASE OF REACTOR PROJECTS ISSUED CONSTRUCTION PERMITS, JULY 1, 1975 - DECEMBER 31, 1977

Source of Delay	Number of Cases
Public Sector Delays	
Substantive Issues	
Safety	
Basic reactor design changes a/	8
Radiological containment	6
External accidents	2
Environmental	
Geology/seismology	7
Meteorlogy/hydrology	3
Site characteristics	2
Other	
Corporate financial/managerial capability	3
Anti-trust	1
Redundancy/Inefficiency	
Bureaucratic delay/data transmission	5
Other government organizations	3
Public Participation	6
Private Sector Delays	
Reconsideration of Need for Power	1
Total Number of Reactor Projects	24

SOURCE: Derived from Nuclear Regulatory Commission, Reactor Licensing Schedule Performance Critique (1977).

a/ Including ECCS (emergency core cooling system).

(usually regarding the reliability of the emergency core cooling system) and radiological containment (the probability of escaping radiation). Leading sources of delay in the NRC environmental review were geological and seismic issues--that is, standards relating to the stability and suitability of the reactor foundation—and meteorological and hydrological regulations concerning the possible interaction between the reactor and the weather or the reactor and ground water. Less frequent substantive sources of delay were issues arising out of site-specific accident studies, such as the ability of the reactor to withstand an airplane impact, and the ability of the utility to finance or manage the reactor project.

Nonsubstantive types of delays in licensing were found to occur less often than substantive ones. While the bulk of delays in the licensing phase of reactor lead time stemmed from safety or environmental issues, six experienced delays because of public hearings or interventions that prolonged the NRC staff's safety or environmental reviews. Eight reactor projects were delayed because of redundant state and federal reviews or inefficiency on the part of the various federal agencies, outside of NRC, involved in the licensing process. Nevertheless, resolution of substantive issues was the most frequent source of delays in the licensing of the 24 reactor projects analyzed for this report, and, as discussed below, accounted for the bulk of the delay they experienced.

Ascribing precise amounts of time to each of these sources of delay is difficult because typically several delay-causing events occur simultaneously. Furthermore, as discussed in the previous chapter, one source of a licensing delay may mask a second; extended safety reviews, for example, may delay licensing of a reactor that would have been delayed for reasons extraneous to the licensing process, such as unanticipated conservation. Thus, any estimate of the average amount of time caused by a particular type of delay during licensing depends to a great extent on judgment.

With this caveat in mind, the bulk of the ten months delay in the average licensing lead time in the sample used for this analysis can be ascribed to the resolution of substantive regulatory issues. Delays of this type averaged about six months, give or take a month, although individual cases varied from no delays to delays of two years or more. Delays attributable to public participation also averaged about six months. There is some degree of overlap, however, between these two categories, since public participants can, by virtue of their presence, extend the NRC review of a reactor's safety or environmental effects. These two categories of delays, however, are roughly equal in impact on total lead time during the licensing phase.

DELAYS IN THE CONSTRUCTION PHASE OF REACTORS

The longest delays in reactor lead time occur, however, after issuance of a construction permit, when the reactor is under construction. *In* the entire sample of 84 reactors under construction (16 of which reported no delays), there was a total fuel loading date slippage of 2,189 months, yielding an average delay of 26 months per reactor; that is, on average, reactors in this sample will take at least two years longer to build than originally planned (see Table 3). It should be pointed out, however, that, on the one hand, the average of 26 months applies to reactors at all levels of completion; thus, because reactors in the sample are on average 27 percent complete, we can expect the average reactor now under construction, when completed, to have delays in excess of 26 months. On the other hand, NRC construction delay data were first collected in their present form in 1974; thus, some older reactors (10 of the sample of 84) reported earlier delays without providing an explanation. The aggregate unexplained slippage in the early phases of these 10 older reactor projects is equal to 196 months of delay, or about 9 percent of all slippages.

About 80 percent of the total amount of delay reported by reactors under construction occurred because of events or decisions in the private sector unrelated to the regulatory decisions of the NRC. More precisely, reconsideration of future demand is the largest single source of construction delays, which is not surprising, because reactor projects are held back until there is sufficient demand for electricity to make the reactor economically worthwhile. These demand reconsiderations, which accounted for more than a quarter of all delay in the sample, have occurred frequently because of the dramatic changes in energy pricing that have taken place in the past five years.

Financial delays, which accounted for close to 20 percent of all delay, have occurred because of the lower demand projections, which make borrowing more difficult to justify, and because of the 1974-1975 capital shortage, when utilities found themselves without prospective purchasers for their securities. Delays originating in the public sector also accounted for nearly 20 percent of all delay in construction, but only 40 percent of that delay is attributable to NRC changes in designs during construction (so-called "backfitting") or other NRC actions. Longer public sector delays occurred because of court decisions or state referendums. Typical of such a non-NRC public sector delay is the case of Callaway Units 1 and 2. In 1976, Missouri voters opted to forbid the costs of construction work in progress from being included in the rate base of public utilities. As a result, the Union Electric Company was forced to defer the Callaway reactors because of the referendum's impact on financing of reactor construction. In short, delays attributable to NRC in the sample of 84 reactors currently under

TABLE 3. AVERAGE AMOUNT AND SOURCES OF DELAYS IN CONSTRUCTION PHASE OF REACTORS CURRENTLY IN PROGRESS a/

Source of Delay	Average Amount of Delay (in months)	Total Amount of Delay (in months)	Source of Delay as Percent of Total Delay
Private Sector			
Labor (strikes, low productivity)	1.02	84.42	3.86
Materials (late or incorrect delivery)	.97	81.66	3.73
Financing (inability of capital markets to generate funds, or failure of internal financing)	4.97	417.50	19.07
Management			
Project delays (problems encountered during construction)	4.72	396.67	18.12
Demand delays (reconsideration of entire project in view of changing demand projections)	7.11	597.42	27.29
Public Sector (NRC regulatory delay, forced retrofits; court and referenda decisions outside NRC)	4.95	415.75	18.99
Unknown (delay occurred before data collection commenced)	2.33	196.00	8.95
Total	26.06	2,189.42	100.01

SOURCE: Derived from Nuclear Regulatory Commission, Construction Status Report, August 1977.

a/ These results are for the sample of all 84 reactors under active construction as of August, 1977.

construction amounted to no more than 173 months in all, or two months per reactor. The effects of the public sector in its entirety amounted to only about 5 months per reactor—about 20 percent of all delay in the sample.

A quarter of all delay in the construction phase resulted from problems that could beset any construction project--labor, materials, and management delays related to construction scheduling. Delays classified as related to project management were found to be unrelated to NRC actions.

Source of Construction Delays at Different Stages of Completion

Delays are different in nature, one would expect, for reactors at different stages of completion. This is true not only because delays naturally accrue as a reactor is being built, but also because of changes over time in the public mood regarding nuclear power, as reflected in private and public sector decisions. Simply put, we expect younger reactors to have less labor, materials, and project management delays, which grow in importance as a reactor is built, and more financial and demand-management delays, because younger reactors were promoted in more recent times, when economic uncertainty and public concern over nuclear power have grown. To test for these effects, three groups of six reactors each were selected from the sample of 84 reactors under construction--the six furthest from completion, but at least 1 percent complete; the six closest to the mean of 27 percent completed; and the six closest to 100 percent completed. The sources of delay were then tabulated for each group (see Table 4).

It should be pointed out first that the limited size of the subsamples employed give rise to some spurious results; for example, zeroes in places where some delays would have been expected, or vice versa. Still, labor, materials, and project-management delays acrue with construction, as expected. The government-related delay category presents somewhat deceptive results: the average of 7.67 months of government-related delay for young reactors stems from one reactor with a 46-month delay (the product of a state referendum), and five with values of zero. This suggests that, with regard to delays originating in the public sector, there is a chance of encountering long delays, and hence great uncertainty on the part of utilities regarding the licensing time of any particular reactor project. This pattern—a low probability of experiencing a very long delay—was also found to be the case for federal/state redundancy delays, and for delays resulting from public participation. Finally, finance and demand-management delays are significant for young reactors (20 months) and mean-age reactors (19.5 months), but small for older reactors (3.5 months). These two categories probably serve as a historical measure: the finance category demonstrates the effects of the 1974-1975 "capital shortage," and utilities' reconsi-

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TABLE 4. AVERAGE AMOUNT OF DELAY IN CONSTRUCTION PHASE OF THREE GROUPS OF REACTORS CURRENTLY AT DIFFERENT STAGES OF COMPLETION, BY SOURCE OF DELAY: IN MONTHS

Source of Delay	Young Group	Mean Group	Older Group
Labor	1.00	0.00	5.18
Materials	0.00	0.00	3.79
Finance	12.83	9.17	1.50
Project Management	1.00	0.00	13.40
Demand Management	7.17	10.50	1.92
Public Sector	7.67	0.00	4.71
Unknown	—	—	14.50
Total	29.67	19.67	45.00
Average Percentage of Reactor Completed	1.00	29.50	96.50
Number of Reactors	6	6	6

SOURCE: Nuclear Regulatory Commission, Construction Status Report, August 1977.

deration of their need for nuclear power has been a major impediment to reactor construction for young and mean-age reactors, owing to revised electric load demands and uncertainty over uranium prices, public opinion, and government policy during their development.

THE FEDERAL ROLE IN EXPEDITING REACTOR LEAD TIMES

These results indicate that government action to expedite reactor lead times, if that is the government's goal, should be directed at the licensing phase; once a construction permit has been granted, no change in government (NRC) regulatory behavior, short of revocations of the construction permit, 1/ will have a major effect. Delays in the construction phase of nuclear reactors could be reduced through better planning of regional power needs, easier access to financing, and through a stronger economy and stronger capital markets.

The uncertainties surrounding nuclear regulation may, however, penalize nuclear utilities in the capital market, making "financing delays" a proxy for uncertainty created by the government. 2/ But CBO has found that the problems of securing adequate financing are more a product of macroeconomic trends and the decisions of state utility regulators than of the nuclear licensing process. Investment analysts are divided today as to whether or not to advise a utility to build a new nuclear unit. Those who are nuclear proponents see no other alternative to significant additions of nuclear-generating capacity, and remain optimistic that both the unresolved "generic" safety aspects of nuclear power—those problems relating to all reactors as such, for example, the disposal of nuclear waste—and the uncertainties in the licensing process will "work themselves out." Analysts who express caution in this regard cite problems such as waste disposal and

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1/ As occurred in the Seabrook case, where a construction permit was revoked after a state court found Seabrook's environmental affects unacceptable. This type of problem is discussed in the next section.

2/ The question of how the securities issued by nuclear utilities are regarded involves understanding the perceptions of investors and securities analysts. The present analysis is based on a series of informal interviews with financial analysts conducted by CBO. A more formal analysis has been conducted by the New York State Public Service Commission, and is available in prepared testimony by Frank Herbert, in the matter of Case 26974, "Comparative Economics of Nuclear and Fossil Fueled Generating Facilities," December 1977, decommissioning costs as factors that could jeopardize an investment in nuclear power, as well as the uncertainties of licensing. Proponents, however, claim that the added costs and expenditure of time created by nuclear licensing need not dissuade the nuclear investor, if state regulators were to allow the incorporation of construction work in progress or an allowance for funds used for construction and increased interest payments into the utility's rate base. If these costs were recouped, such delays would be cost-free to the utility.

A formal analysis of the treatment of nuclear utilities' securities was conducted by the New York State Public Service Commission. The commission found that a utility's use of either coal or nuclear fuel had no effect on the price it offered investors for its securities. Instead, the ratio of dividends paid to the book value of the utility, the attitude of the relevant state regulatory commission, and the rate of return on equity were all found to be important in determining the price of a utility's securities. Thus, while reactor licensing does create some uncertainty, it is not enough to dissuade significant numbers of investors from considering affected utilities' bonds.

The "bunching" of financial delays, also suggests that they are cyclical in nature. The great majority of financial delays for reactors now under construction occurred in the "capital shortage" period of late 1974 and early 1975. Given prediction of a slowly recovering economy in the immediate future, CBO sees financial delays receding as a contributor to longer lead times. This should be contrasted to effects of downward demand forecast revisions, which have occurred steadily between 1974 and the present. CBO estimates that such demand revisions, stemming from lower demand growth rates, will be increasingly important in the future, as conservation and the use of alternative forms of power generation or energy provision (such as passive solar) become more common.

THE COST OF DELAYS IN REACTOR LICENSING AND CONSTRUCTION

CBO has estimated that the cost of a month's delay in reactor lead time is approximately $8.9 million for reactors undergoing licensing and $10.6 million for reactors during the construction phase (see Table 5). These costs were estimated for a 1,100 megawatt reactor planned in 1976 for service in 1987. Such a reactor would now be undergoing construction permit review. These costs are of three types: the costs of replacement energy, the inflated costs of construction after the delay, and the cost of carrying charges on capital already expended on the project. The method of calculating these costs is presented in Appendix B.

TABLE 5. COSTS OF A MONTH'S DELAY IN LICENSING AND CONSTRUCTION PHASES OF A 1,100 MEGAWATT REACTOR, ANTICIPATED ON LINE IN 1987: IN THOUSANDS OF DOLLARS

Type of Cost	Licensing Phase	Construction Phase
Energy Replacement	2,518	2,518
Inflation	6,105	2,677
Interest	250	5,393
Total	8,873	10,588

CHAPTER V. THE NUCLEAR SITING AND LICENSING ACT

The objective of the Nuclear Siting and Licensing Act, first introduced in March of 1978 and to be reintroduced in the 96th Congress, is to reduce the total lead time of reactors from their current level of 10 years to 6. The major changes proposed in the legislation are:

- Standardization of reactor and plant designs, which would allow the NRC to issue reactor vendors, such as General Electric or **Westinghouse,** a "license to manufacture" pre-approved reactors or reactor parts for a period of five years;

- Early site review, which would allow the NRC to approve, before issuance of a construction permit, proposed reactor sites for a period of 10 years;

- The use of adversary public hearings in the licensing process would be limited, but a pilot program for intervenor funding and public participation the planning stage of reactor projects would be initiated;

- Mandatory review of individual construction permit applications by the NRC's Advisory Committee on Reactor Safeguards (ACRS) would be eliminated;

- State and federal reviews would be coordinated under NEPA, that is, the NRC would be allowed to delegate environmental reviews, as mandated by the National Environmental Policy Act, to individual states;

- The NRC would be allowed to issue operating licenses together with construction permits, and to issue interim operating licenses before operating license hearings are completed.

With the exception of changes in operating license practices, all of these reforms are aimed at the licensing phase of reactor lead time.

STANDARDIZATION OF REACTOR AND PLANT DESIGN

The Nuclear Siting and Licensing Act would authorize the NRC to issue preliminary and final design approvals to reactor vendors either through rule-making or through the issuance of a "license to manufacture" without application fees. These permits would be valid for five years with a possible three-year renewal. Standard designs could, however, be revoked, suspended, or amended by the NRC if "major new considerations" affecting public health, safety, or national security were discovered.

In fact, standardization will probably be promoted by the nuclear industry itself, in order to minimize the per unit costs associated with plant planning and design. For example, a standard 1150 megawatt reactor manufactured by Westinghouse, called SNUPPS (Standard Nuclear Power Plant System), is now being incorporated into nuclear power plants by the Union Electric Company (Callaway 1 and 2), Kansas Gas and Electric Company (Wolf Creek), Northern States Power Company (Tyrone 1), and Rochester Gas and Electric (Sterling 1).

In addition, there is some history of standardization in use. NRC has issued a report on its experiences with standard reference designs for nuclear steam supply systems. 1/ Three of those designs have been employed by utilities—one design by Westinghouse, one by Combustion Engineering, and one by General Electric. The NRC study demonstrated that its average staff time for safety review was less for standard designs than it was for custom-designed plants. Nevertheless, large amounts of NRC staff time are required to investigate and approve the design of a standard nuclear steam supply system: the NRC data imply that four or five utilities must employ a standardized design in order to justify the staff time expended on it. A number of nuclear vendors are now applying for preliminary and final design approvals for standard designs, and as many as 12 standard designs for nuclear steam supply systems and the balance of plant could be approved by the end of the 1970s. Some of these designs will be used in tandem, but it is not clear that standardization will achieve real savings of time in the NRC safety review, because, unless reactor orders increase, utilities may not use the approved designs in sufficient number.

The SNUPPS case has, however, apparently reduced NRC staff time. The use of one design for four power stations enabled the NRC to cut staff time spent on safety review from an average of 10 to 2.5 man-years per application. The replicate plant concept (in which a plant applies for a construction permit using a design that the NRC has already approved for another plant) is also now being employed by utilities—four utilities have filed such applications. Time and staff savings are beginning to grow,

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1/ Policy Statement on Standardization of Nuclear Power Plants (1977).

although initial savings are difficult to obtain, subsequent applications replicating the same design appear to move more rapidly, as NRC staff becomes familiar with that design.

The standardization program should help shorten the safety review process; it could reduce the licensing process by a year, if other aspects of licensing could also be expedited.

The drawback associated with this proposal is the necessary concommitant freezing of nuclear technology. The standardization of a design for five or more years implies that no safety innovations can be ratcheted on to that design. This raises a key issue that Congress must face: is reactor technology mature enough to warrant significant freezing of design?

Regarding this issue, it should be pointed out that according to the NRC, over 100 "unresolved issues" concerning the safety of nuclear reactors remain. These include more than 30 issues for which resolutions could, in the eyes of NRC, be applied to all affected reactors and "provide a significant increase in assurance of the health and safety of the public." Examples of these unresolved safety issues are the occurrence of "water hammers" (slugs of water pushed through the reactor plumbing by steam, damaging pipes and valves) and nozzle-cracking in feedwater heaters (raising the possibility that vessels carrying radioactive water and vapor will fracture). The absence of a permanent resolution of these issues has not, however, halted the present licensing process. These issues are currently resolved on a case-by-case basis. Nevertheless, they may be the target of retrofits. Moreover, the NRC's reappraisal of the Rasmussen Report may raise new issues regarding the safety of currently operating reactors and the designs of forthcoming reactors.

The majority of the issues currently seen as capable of providing a significant increase in the public's safety could be resolved by 1980. Some of the resolutions reached by NRC staff will no doubt meet the standard of "significant new information relevant to the design," which the bill defines as the criterion for mandating changes in standardized designs. Thus, some changes in standardized designs must be anticipated, which would undermine some of the possible benefits of standardization. It should also be pointed out that current NRC procedure prohibits backfits of designs (Rule 50.109) unless it can be demonstrated that they provide "substantial additional protection." It is difficult to imagine that the bill's criterion that changes in standardized designs may be mandated only if they fail to "comply. . . with regulations for the public health and safety" would be more stringent than the current backfitting rule. It is therefore unclear that the bill's provisions would eliminate more backfitting then now occurs.

A meaningful standardization policy would eventually reduce paperwork and regulatory lead time, but it would also bring about further savings in the construction period, if nuclear vendors felt confident enough in the permanence of reactor design to develop an inventory of standardized parts. Creation of such an inventory, which now, understandably, does not exist, could reduce construction time by six months. But given the chance that The NRC may require safety innovations in the next two years, the nuclear industry may not receive the assurance that permanent design standardization has arrived. Thus, standardization will probably not reduce construction lead times.

EARLY SITE REVIEW (ESR)

The NSLA would allow site banking for future reactors, in the hope that site-related environmental issues could be resolved before reactor licensing. Under present policy, only individual site-specific issues can be resolved, and an entire site cannot be approved before issuance of a construction permit.

As proposed in the Nuclear Siting and Licensing Act, early site review could operate as follows: A utility's application for an early site review would respond to the demands of the NRC for environmental data, and would include a rough indication of its future need for power. Final proof of its need for nuclear generated power would not be requested until the construction permit review of the reactor itself. The ESR application would thus include rough specifications of the estimated level of radiological and other effluents, and the type of cooling system that would be used—data necessary to conduct an adequate environmental review. An ESR permit would be valid for any reactor built within those estimates and rough specifications. The permit would be valid for 10 years and would allow the applicant utility to prepare for construction and perform limited construction activities at its own risk.

Under current policy, a utility can apply for only a limited early site review (LESR), which deals with a subset of ESR considerations. Like ESR, LESR has the advantage of resolving, as far as the NRC is concerned, important issues at an early stage of the licensing process. Without new statutory authority, however, the NRC is unable to issue advance site permits, and therefore cannot allow basic construction work, such as assemblage of construction shacks, excavation, land clearing, access roads, and so forth, to begin. Such activities now can be conducted in advance of issuance of a construction permit only under a limited work authorization, and the issuance of a limited work authorization requires clarification of a broader set of issues than a single site review.

The advantages of early site review can be summarized: if successfully implemented, the procedure would allow early resolution of environmental questions before substantial resources are devoted to developing and defending the reactor design itself before the NRC. ESR hearings would also require public participation, if any, early in the licensing process, and, if coupled with active enforcement of the proposed regulation prohibiting issues with "prior opportunity," it would limit interventions to non-site matters later in the construction permit application process. Licensing times under ESR could be expedited by doing preparatory work before the reactor is needed. In all, if ESRs are carried out before construction permit review, environmental reviews could be shortened by a year.

These benefits, however, might not be realized, inasmuch as ESR-approved sites would have to be referred to states for their approval. State requirements for environmental review can be more stringent and time-consuming than NEPA standards, and they might require more data than the NRC's early site review, particularly in nonenvironmental issues, such as the utility's need for power, alternative sources of power plant specification, and so forth. Thus, although the federal regulatory process could expeditiously approve a site under an ESR arrangement, a state could hold up site approval under its own laws. (The problem of state/NRC coordination is discussed below.)

Furthermore, although early site review would reduce the duration of construction permit reviews, it could lengthen the planning time involved before the nuclear steam supply system order and subsequent construction permit application. The latter could occur because the preparation and evaluation of the environmental data needed for an early site review would precede development and review of the application for a construction permit. Thus, ESR would not benefit utilities that do not have the luxury of planning a reactor that is not immediately necessary. Rather, ESR moves consideration of site-related issues to a point in time before the utility's need for new power is felt. Moreover, the specifications of an ESR must therefore be valid for a longer period of time than the site specifications used in a construction review application. With respect to some site-related issues—notably population density—planning horizons might be extended long enough to make projections uncertain or meaningless. The advantages of ESR would be eliminated and, in fact, the review process could become even longer, if such crucial factors as population density change significantly during the planning period for which the ESR is valid. Nor is an ESR without cost to the utility. Not only does the site review require a thorough analysis of meterological, seismic, population density, urbanization trends, and other factors, but the basic design of the plant must itself be sufficiently known to provide parameters for effluent levels and other design-related characteristics with which the site must be proved compatable. The cost of such work can exceed $10 million. Thus, *a* further problem is the integration of site and reactor design parameters. In practice, the suitability of a site is not independent of a reactor design, and regulatory effort will have to be expanded to coordinate the two effectively.

An additional drawback of ESR is the incentive it provides towards "grandfathering," which could bias regulatory decisions. Grandfathering occurs when a utility spends large sums of money on site preparation and advance construction work, and then argues that denial of a license would represent a severe economic loss. Such a process undermines the integrity of the licensing process, particularly with respect to the decision as to whether nuclear power is needed or whether a plant is needed at all. For example, the cost-benefit analysis of a nuclear plant used in an environmental impact statement uses the cost of completing a nuclear facility in its calculation as opposed to the entire cost of building it, which understates the true costs of the plant. That methodology allows grandfathering to circumvent the function of licensing. The NSLA states that costs incurred prior to construction permit issuance are brought on at the utility's risk, but such sunk costs have been treated deferentially, despite existing caveats not to do so. ESR grandfathering would especially undermine the present NEPA analysis, which weighs the costs and benefits of the proposed nuclear facility against the costs and benefits of alternatives.

Nevertheless, ESR could have ameliorated some recent delays in the licensing process. Clinton 1 and 2, North Anna 3, Diablo Canyon 1 and 2, Pebble Springs 1 and 2, and Pilgrim 2 all experienced delays because of geologic faults near their sites, with an average delay of over a year. In most, if not all of these instances, an early site review might have resolved the seismology issue far earlier in the licensing process. This would have been extremely advantageous in the case of Diablo Canyon, where fuel loading of a virtually completed reactor now awaits a second review of the seismological character of the Hosgri fault, located two miles away. Although the tests indicating the existence of the fault had not been run when the construction permits were issued for the two Diablo Canyon units, (these tests were performed by Shell Oil in the late 1960s), the chance of avoiding a situation in which a completed reactor stands idle is worth pursuing. In the other cases, a body of seismic data that could have been applied to an early site review did exist.

HEARINGS AND INTERVENTIONS

The issue of hearings and interventions is a controversial one. On the one hand, nuclear industry representatives and nuclear power proponents often claim that public participation in NRC hearings is a major source of delay and uncertainty in the licensing process, and that the goal of many intervenors goes no. further than simple obstruction of nuclear power plant siting. On the other hand, defenders of the intervention process consider it a way of preserving the representation of affected communities in the siting decision.

The Nuclear Siting and Licensing Act makes the following proposals in relation to public participation:

- o The subject matter of interventions would be limited to topics for which there has been "no prior opportunity" to hold a hearing, unless relevant new information can be proved to have been discovered;

- o The NRC may give priority to construction permit applications of utilities that allow "advanced planning"; that is, allow the NRC and the interested public to participate in the planning of the reactor. This procedure would lead to an early identification of issues that could become the subject of subsequent intervention. This, however, it would not be a mandatory procedure, and could not be used to formally resolve issues at the planning stage of the process, before actual review;

- o A pilot program would be set up for the limited funding of some intervention on the part of the public. Funding decisions would be determined by the NRC, based on criteria including the intervenor's interest, access to alternative funds, and the effectiveness and importance of the intervenor's contribution. Payment would not necessarily extend to total compensation;

- o Legislative hearings would replace adjudicatory hearings concerning environmental matters, unless the hearings officer, who may impose an adjudicatory hearing, finds a factual difference between the parties.

Resolution of the question of interventions is a political matter. When coupled with other provisions—in particular, coordination of federal and state regulations and early site approval and standardization—enactment of this proposal should make hearings go somewhat more quickly, owing to the "no prior opportunity" criterion for admissable intervention. For example, this test would rule out intervention on site-related environmental grounds, even if a site permit has been issued 10 years before the construction permit application. This procedural rule places a great premium on foresight, particularly when applied to early site review and standardized design. Nevertheless, such foresight is necessary to avoid the relitigations that would render early site reviews and standardized design approvals ineffective in reducing lead times. Thus, the successful implementation of early site review and design standardization would to some extent preclude public participation at the construction permit stage.

The NSLA provisions for advance planning would allow the NRC to encourage public input into a utility's planning process before its formal application for a construction permit. As noted earlier in this report, delays early in the licensing process to accommodate the concerns of intervenors have often served the purpose of avoiding longer delays in public hearings later in the review process. Open advance planning could lead to an early identification of issues, which could be resolved before a reactor design is formalized and its application docketed—a procedure that would at once protect public participation and expedite the licensing process. Under NSLA, however, findings resulting from advance planning would not be binding, which would reduce this effectiveness of the proposal.

The bill also substitutes legislative hearings for adjudicatory ones. Adjudicatory hearings grant intervenors the right to cross-examination and the right of discovery, the traditional tools of a participant in an adversary proceeding. Under a legislative format, questioning is conducted by a hearings examiner, who may, if he so chooses, use lists of questions submitted by the parties. Should the transcript of a legislative hearing reveal a difference between the parties concerning a matter of fact, an adjudicatory procedure would be carried out. This "hybrid" form of hearing reverses the past practice of waiving the right to an adjudicatory hearing should both parties find no factual difference between them. Instead, an adjudicatory hearing would require proof of a factual disagreement. 2/

The "no prior opportunity" rule would probably eliminate some hearings issues, but it might present legal questions as to whether or not a prior opportunity existed. Should such legal challenges develop, the time

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2/ It should be pointed out that NRC does have procedural rules for the conduct of hearings, which deal with such matters as: the summary disposition of issues without merit, the exclusion of issues for which there exists an applicable precedent, or the identification of adjudicable issues. In their study "Nuclear Power Plant Licensing: Opportunities for Improvement," 1977, the NRC Study Group concluded that "no data has been revealed by this study which suggests, either that there is any deficiency in the available procedural tools, or that they were not fully used. . . In any event, vigorous application of these rules is one of the beneficial actions which can be taken under existing laws. . ."

saved from the "opportunity" rule could be eradicated. Persistent intervenors might also force the courts to decide whether issues should have been litigated by adjudicatory as opposed to legislative procedures.

There are grounds for believing that open advanced planning is a useful innovation, and consideration might be given to making this procedure mandatory. This is based on the assumption that as long as the concerned public has access to the licensing process, its concerns and beliefs should be accommodated earlier, as opposed to later, when the costs of accommodation, in both time and money, are greater. Utilities are understandably fearful of admitting intervenors into the planning process. Yet groups perceived as adversaries are capable of finding areas of agreement and compromise, if provided with the opportunity. A model for such cooperation can be found in the National Coal Policy Project, sponsored by the Center for Strategic and International Studies of Georgetown University. The Coal Project consisted of a panel of industrialists and environmentalists who met throughout 1977 to formulate principles concerning coal production on which they could agree. This procedure for finding "common ground" could be incorporated into the nuclear licensing process.

The ultimate impact of the NSLA proposal to authorize limited funding of intervenors is unclear. Insofar as the funding proposal falls far short of a blanket funding of all intervenors, it may not have the presumed effect of encouraging intervention—and hence delay—in the licensing process. Subsidizing intervenors may also improve the specificity—and hence the quality—of interventions, as well as make the process appear fairer to intervenors who can be "out financed" by utilities.

Finally, despite allegations that the intention of intervenors in public hearings is to obstruct the licensing process, they have made productive contributions to the regulatory process. Several generic issues—that is, those common to all reactors--were first raised by intervenors, for example, the reliability of the emergency core cooling system, and fuel rod densification. In some instances, NRC staff actions on questions, such as radiological emissions or seismic considerations, have vindicated the positions taken by intervenors. An expression of this view can be found in a 1974 decision of the Atomic Safety and Licensing Appeal Board, which rejected a claim by Gulf States Utility Company that intervenors had, in general, "nothing to contribute." The ALAB stated that:

> Our own experience . . . teaches that the generalization has no foundation in fact. Public participation in licensing proceedings not only 'can provide valuable assistance to the adjudicatory process', but on frequent occasions demonstratably has done so ... many of the substantial safety and

> environmental issues which have received the scrutiny of licensing boards and appeal boards were raised in the first instance by an intervenor.
>
> This is not to say that every intervenor is equipped to make a meaningful contribution . . . (but) • • • the Commission's summary disposition rule provides an ample safeguard against an applicant or the regulatory staff being required to expend time and effort at a hearing on any contention advanced by an intervenor which is manifestly unworthy of exploration.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) REVIEW

In 1957, when ACRS was created, each new reactor design was significantly different from the one preceding it. This is no longer the case. Commercial reactor designs are now sufficiently homogeneous so as not to warrant mandatory ACRS review of all nuclear reactor proposals. Elimination of mandatory ACRS review of every reactor proposal would save two to three months per reactor license—the time now allocated to ACRS hearings.

Moreover, ACRS staff time savings resulting from this change could be applied to ACRS review of standardized designs. As noted earlier, standardization could reduce licensing time if approved designs are used often enough to justify the time spent by NRC staff in approving them. Allowing the ACRS to involve itself heavily in the process of approving Preliminary and Final Design Analyses would make the requisite number of applications needed to justify the effort expended to approve a standardized design that much smaller. The ACRS would also be able to devote more attention to early site reviews, if freed from its responsibilities regarding each application for a construction permit.

This is not to argue that ACRS review is redundant or without effect. In the Diablo Canyon case, the ACRS insisted that the utility and NRC continually re-evaluate the former's assumptions concerning seismic activity near the plant. Thus, ACRS can provide significant insight into problems regarding a reactor, and the NSLA would allow the ACRS to become involved in such cases as it sees fit.

COORDINATION OF STATE AND FEDERAL REVIEWS UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

The Nuclear Siting and Licensing Act attempts to strike a balance between the right of states to make their own decision concerning power supply priorities while providing for a more predictable and expeditious licensing process. The bill would authorize the NRC to approve programs submitted by the individual states for making evaluations and determinations regarding environmental needs for power issues. If approved, a state review process would replace the NRC review process, and state decisions concerning environmental standards and needs for power would be binding at the NRC level. The NRC would, however, retain its authority over radiological issues. If a state's program *is* not approved by the NRC, states could still transmit data to the NRC for its consideration, but without the weight of a final finding.

The substance of state and federal reviews of environmental issues and a utility's need for power is often the same, yet their hearings are often held sequentially, thereby causing delay. Further, approval by one does not imply approval by the other, thereby adding uncertainty as to outcome. The matter is also complicated by the fact that some states pursue a strict regulatory process for nuclear power, requiring environmental reviews of two years of intense consideration of alternative sources of power. This reflects the fact that different states have different attitudes towards nuclear power. Preemption of states' review would deny these states their existing right to view nuclear power as a least or less preferred alternative. States' rights have been preempted, however, in the area of radiological emissions by the Supreme Court, although the recent amendments to the Clean Air Act have given states the right to review radiological emissions.

Although state regulation is an obstacle to the licensing of only a subset of all reactors, delays of over a year have been experienced because of replicated hearings, 3/ which this proposal could eliminate. The bill would also allow NRC to retain control over environmental standards, through its power to approve or disapprove state review procedures and its authority to suspend funding and support if the approved procedures are not carried out. Thus, this proposal could expedite licensing without compromising environmental standards, unless such a compromise were to become part of an official policy of the NRC.

3/ See New England Federal Regional Council of Energy Resource Development Task Force Bulk Power Committee, "A Report on Nuclear Power Plant Delays in New England" (Nov. 1976).

Two particular areas of state reviews raise issues concerning the efficacy of NSLA proposals regarding public intervention. The first is the matter of substituting legislative for adjudicatory hearings; the second is authorizing states to impose time limits on deliberation and hearings. Although these proposals carry the promise of expeditious terminations of lengthy proceedings, the final result may not be as intended. This is because time limits provide utilities with an incentive to withhold information, if faced with an adversary proceeding and intervention. Although such potential stalling tactics would not extend hearings past their deadline, they could result, not only in suboptimal decisions, but also in courts finding that sufficient evidence had not been presented and that intervenors had therefore been denied due process. Such an outcome could eliminate the time savings gained by the imposition of hearings deadlines.

This legislation does not, however, preempt the right of states to place more stringent licensing requirements on reactor projects than those of NRC. Thus, while this proposal would expedite reviews by eliminating duplication, it would not change the requirements of the more stringent states.

This system of federal/state coordination could have played a constructive role in recent cases. The LaSalle project, for example, underwent hearings before the state of Illinois Commerce Commission in 1971 concerning environmental questions raised by an intervening group of local farmers. Many of the same issues were raised in 1973 hearings before the ASLB, creating a six-month delay. In the case of the Jamesport reactor, a three-year New York State review, requiring more material than the NRC review, was conducted. Since New York State's hearings and review process is among the nation's most diligent, formal approval of its findings by NRC would facilitate reactor licensing.

CHANGES IN OPERATING LICENSE PRACTICES

The NSLA also proposes the use of "one-stop" licensing for reactors. Under a one-stop licensing system, both a construction permit and an operating license would be issued after the construction permit review. This is not possible under current statutes.

Operating license reviews consist of checking to see if the design submitted for the reactor has been properly carried out. Public hearings are held on this issue or on any other issue that an NRC hearings officer will allow. Operating license hearings are rarely a major source of delay in getting reactors on line, except in cases where new and significant information has been discovered. Otherwise, operating license review is usually timed to coincide with the completion of plant design and construction.

Nevertheless, the operating license review does represent another source of uncertainty to the utility. The one-stop system, as proposed in the Nuclear Siting and Licensing Act, would diminish some of this uncertainty, particularly by eliminating operating license hearings, except, as the Nuclear Siting and Licensing Act states, when there is "prima facie" evidence that "significant new information" or a "significant new issue" exists, or if the terms of the construction permit/operating license have been violated. Thus, a utility would be subjected to an operating license hearing and review only if substantive new discoveries were made concerning the reactor.

This gain in certainty may, however, be achieved at the expense of a possible loss of time. A problem with the one-stop system is the quantity and specificity of information that the utility would have to provide the NRC. The appropriateness of the information provided by utilities to the NRC is a perennial issue, expressed in the "doctor-patient" hypothesis concerning reactor delays, which states that utilities frequently lack the technical capability to deal with the NRC directly. Several reactors in the licensing sample investigated in Chapter IV were delayed because of poor data transmission.

The NRC states that attempts to secure better quality information on construction permit applications from utilities have met with some success, yet much of the information that the NRC receives is still boilerplate language that is available on computer tapes from architect/engineering firms and reactor manufacturers. One-stop licensing would increase the requisite amount of information needed to process an application. Under one-stop licensing, most of the reactor would have to be designed by the time of construction permit review, as opposed to the present 30 to 35 percent. Insofar as on-site inspection of a reactor undergoing construction would be the NRC's primary vehicle for making final safety determinations now made in the operating license review, a far greater degree of specificity would be required when docketing a one-stop license then at present with only a construction permit. Moreover, the two rounds of questions issued by NRC staff, and delays on the part of utilities in answering them, frequently delay the construction permit review. This is not to argue that less information should be required when docketing a construction permit application (although an NRC review of required information for construction permit application acceptance and further NRC cooperation with construction permit applicants would be productive in reducing long licensing periods), but that requiring more information could possibly eradicate any time savings generated by eliminating many operating license reviews. Furthermore, utilities, fearing a rigorous adversary atmosphere, are loathe to put forward more information than they believe necessary. Thus, the greater amount of information required to process a construction permit/operating license may elicit a reticent response from utilities wary of the regulatory

The bill also allows for the issuance of interim operating license's while operating license reviews are being conducted, which would allow a reactor to operate if in response to an "urgent public need." This is likely to speed reactor start-ups only when an unlicensed reactor was presumed safe before formal hearings.

THE IMPACT AND SIGNIFICANCE OF THE NSLA

Impact of the NSLA on Lead Time

In estimating the reduction in lead time that would probably result from enactment of the Nuclear Siting and Licensing Act, it should be pointed out that the time savings generated by each reform proposed by the act cannot be added to calculate "total savings." This is because many of the delays that individual reforms address occur concurrently; therefore, in order to reduce total lead time, several reforms must operate simultaneously. The total impact of the NSLA is judged by this analysis to reduce total lead time by 18 to 24 months, if completely and effectively implemented. Creation of reactor component inventories by the nuclear industry would be the only measurable effect of the NSLA on the construction phase of lead time. If no inventory of parts were created, the savings in time would occur only in the licensing phase, which would be reduced by 12 to 18 months. A full 18-month saving would reduce the capital cost of a reactor by 9 percent, in turn reducing the cost of nuclear-generated electricity by about 7 percent. These savings could not occur, however, until the later 1980s.

The standardization section of the Nuclear Siting and Licensing Act is not a significant new innovation when compared to procedures already being developed within the NRC; however, this legislation would give standardization the support of the Congress. An effective standardization program could reduce licensing times by a year. Furthermore, inventorying of parts could reduce construction times by six months, if ratcheting of standardized designs were discontinued. The latter seems unlikely, however, given the large number of unresolved issues pending NRC attention.

Early site review could produce savings of six months to a year, in cases in which the time is available to perform longer advance planning activities regarding the site. These savings would occur because site banking would reduce the review necessary to obtain an limited work authorization, which generally takes 12 to 15 months and permits basic site work. Combined ESR and standardization could reduce licensing and construction times by two years, if standardization is sufficiently rigid to promote enough industry confidence to merit its stockpiling of crucial forgings and parts, and if utilities have the flexibility to move site reviews forward from the construction permit review period to the advance planning period.

The effect of steps taken to expedite public hearings are uncertain because of the possibility of a new set of legal contentions concerning implementation of the new procedures and the possible denial of due process. More effective management of hearings by ASLB hearing officers, using existing regulations governing the scope and conduct of interventions, could prove as effective as the bill's proposed reform.

Delegation of some NEPA authority to the states could reduce lead time by several months for reactors that undergo stringent state reviews, insofar as redundancies with the NRC's NEPA review would be eliminated. Savings resulting from elimination of mandatory ACRS review and elimination of operating license hearings through one-stop licensing would be minimal.

In sum, if standardization were effectively implemented and if early site reviews provided definitive approvals for sites, despite the possibility of changing demographic parameters during the planning period, the licensing process would consist of an analysis of site/design interface and NEPA compliance, including the question of the utility's need for power. Viewed optimistically, this procedure could take from 12 to 18 months, in the absence of serious and legitimate contention by intervenors or NRC staff. This would represent a savings of approximately one year, not counting additional advance planning time.

Will New Obstacles Arise in the Future? It should also be pointed out that new obstacles to the expeditious licensing and construction of reactors may take place in the future, just as financial delays became frequent several years ago, owing to capital shortage problems. Conservation and the technological maturation of alternative technologies, as stressed in the National Energy Plan, may force re-estimation of the need for power from the central station delivery system. Similarly, waste disposal and decommissioning problems and costs may force economic reappraisals of the nuclear option, making the "need for power" and the comparison of nuclear with alternative sources of power more important licensing issues than they have traditionally been. Nevertheless, nuclear power, with its high capital costs and low operating costs, is an attractive proposition for regulated utilities; thus, the need for nuclear power may overshadow safety and radiological obstacles to quick licensing in the future, especially as NRC resolves, for licensing purposes, generic safety issues. This would not affect licensing time, but rather could force utilities to defer construction of plants with approved construction permits until demand catches up with the new levels of capacity that nuclear additions would represent. This situation may indicate the delays of the 1980s, which could necessitate a more rigorous and regionally oriented system of demand estimation for electrical generating facilities than is provided by the Nuclear Siting and Licensing Act.

The Significance of NSLA: The Issue of Maturity and Acceptability

The Nuclear Siting and Licensing Act represents a movement in the direction of a full-scale endorsement of nuclear power as a mature technology. The essence of a mature and acceptable technology is that its risks to the public are known and are no greater than the risks the public knowingly endures. At that level of risk, improvements would be legitimized in terms of their cost effectiveness, as opposed to a simple concern for safety.

The question of the maturity of nuclear technology has, however, recently been called into question as a result of the NRC's withdrawal of support for the Rasmussen Report. In the absence of this report, no official estimate of the chances of a nuclear accident exist.

The current bill heads in the direction of an endorsement of nuclear power as mature and acceptable by:

- Implementing formal procedures for licensing standardized designs;
- Suggesting consideration of the "cost of additional safety requirements";
- Using interim operating licenses; and
- Eliminating adjudicatory hearings concerning the "need for power" and standardized design components.

The licensing of standardized designs, given its implicit commitment to minimization of future design change, represents a willingness to regard the present state of the art in reactor radiological safety and environmental acceptability as sufficiently developed so as to be predictable and acceptable. Although the bill clearly does not exclude the possibility of ratcheting safety innovations onto standardized designs, compromises of this willingness would render standardization ineffective. Similarly, the bill's mention of consideration of costs of additional safety requirements raises the issue of the applicability of cost-benefit analysis to marginal safety improvements. This leads to the question of whether or not implementation of a potential safety innovation would be postponed if it were extremely costly, or conversely, if the government would be willing to shut a plant down or allow a plant to close if safety improvements were too costly. In 1974, the Indian Point 1 reactor was closed because its parent utility did not want to absorb the cost of installation of an Emergency Core Cooling System, an important safety innovation. Willingness to impose such innovations, regardless of the cost and consequences, can be seen as expression of a judgment that nuclear technology was not mature, and hence warranted a regulatory posture that minimized the chances of a catastrophic accident of unknown probability. It is unclear whether or not the proposed programs of standardization will, when confronted with new safety technology, maintain the assumption of technological maturity upon which many of the regulatory reforms proposed by the NSLA are based.

The proposed use of interim operating licenses represents another small step towards an implied judgment of maturity. Operating license review has traditionally served the function of a last check by the NRC to ensure that all conditions outlined in the construction permit and its subsequent amendments have been met. Allowing a reactor that has not had a final review of its complete design to operate for a year, with possible extensions, reflects the belief that a reactor not yet in compliance with specified safety standards presents no new risk to the public.

The elimination of adjudicatory hearings on NEPA issues, particularly the "need for power" issue, also reflects movement towards a judgment of maturity. Previous policy has been to view nuclear power issues as so sufficiently uncertain as to merit adversary proceedings; however, that standard is not reflected in the elimination of direct cross-examination in hearings concerning electricity demand and its provision, or other NEPA issues. Nevertheless, the bill preserves most of the rights of participation now found in the licensing process. Similarly, states would be permitted under NSLA to make a need for power determination, but utilities would be able to provide the data necessary for such a review as little as 60 days before hearings on the subject, which may not allow enough time for a thorough review.

In sum, the Nuclear Siting and Licensing Act could shorten the licensing phase of reactor lead time by 12 to 18 months. The NSLA does not, however, exhaust all approaches to licensing reform and reductions in the lead times of nuclear reactors. In the next chapter, two other approaches are described: one would require no new legislation; the other is one in which the government endorses a "full-push" towards nuclear power.

CHAPTER VI. ALTERNATIVE APPROACHES TO REDUCING REACTOR LEAD TIMES

Reforms proposed by the NSLA do not exhaust all possible reforms or approaches to the problem of increasing reactor lead times. This chapter discusses reforms that could be internally implemented by the NRC and coordinated with the NSLA; an alternative "full push" approach, in which reactor lead time is reduced through a redefinition of the roles of relevant government agencies and the concerned public, is then described.

IN-HOUSE NRC ACTION

Without new statutory authority, the NRC could take several actions to reduce licensing times. Many of these proposals can be found in NRC's "Denton Report." 1/ The NRC could make greater use of existing procedures to resolve generic issues, which are now usually litigated on a case-by-case basis; for example, uranium availability and the environmental effects of uranium mining and processing, the environmental effects of alternatives to nuclear power generation (coal), reactor decommissioning, and fuel reprocessing. Moreover, insofar as nuclear power is now a contributing source of electricity supply, issues such as the potential supply of uranium and the treatment of long-term radioactive wastes could be resolved as a matter of formal national policy. There are also issues that do vary on a case-by-case basis and hence cannot be resolved generically (such as a utility's financial capability or its alternatives to nuclear power). But these could be resolved by using "generic methodology"--that is, by establishing a methodology that can be used in each case to resolve an issue even though any two cases may have different specific circumstances.

Generic resolution has several advantages. First, as is obvious, NRC reviews would become shorter as more project-specific issues are defined generically. Second, generic resolutions would limit intervention to issues related to an individual reactor and site; when used to define a methodology, it would limit intervention to the question of whether or not the methodology had been properly applied. Furthermore, it would add certainty to

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1/ Nuclear Power Plant Licensing; and Opportunities for Improvement (June 1977).

NRC decisions, and provide utilities with an a priori understanding of NRC's position on salient issues. In cases of fact, generic resolutions of issues could be reached through hearings; in cases of policy, generic rule-making could be used to establish policy. For example, a rule establishing a dollar value for radiation releases has been applied to a large number of cases.

The major disadvantage of rule-making is the possibility of subsequent judicial review affecting a large number of completed applications. A single court decision may have a profound effect on the licensing process. For example, in July 1976, a federal court of appeals decision invalidated a then-existing NRC rule for considering the environmental effects of the nuclear fuel cycle in construction permit and operating license proceedings, and the NRC was forced to suspend granting of limited work authorizations, construction permits, and operating licenses for more than three months, until a new rule was prepared. On balance, however, additional rule-making, where appropriate, would probably be an effective innovation in the licensing process, not only because of its ability to resolve generic issues, but also because it would represent an important step towards defining a national policy concerning nuclear energy. If rule-making is to be put into wider use, however, guarantees would need to be provided for continued public: input into rule-making proceedings, inasmuch as rule-making could not substitute for hearings where factual questions are at issue.

The NRC could, without new statutory authority, continue to promote the granting of limited work authorizations, which may be issued after the environmental review of the proposed plant has been completed. Most such authorizations allow the utility to do only basic site preparation work, although a second type (an LWA-2) allows the installation of structural foundations. The function served by limited work authorizations--giving utilities a head start on construction activities--could be furthered by a policy of providing, on a case-by-case basis, a specific list of permissible preparation and construction activities. The Nuclear Siting and Licensing Act reiterates the authority of the NRC to initiate such a policy.

The quality and quantity of the information received by NRC is often a crucial variable in determining reactor licensing times. Although two rounds of NRC questions and applicant answers are the rule after docketing of the applicant's preliminary safety analysis report (the safety component of the construction permit application), the duration of those rounds varies greatly. The NRC currently meets with applicants to help them prepare for docketing, and issues a standard format guide for applicants to use in preparing their applications. The NRC is considering both additional pre-docketing meetings and a reassessment of the format guide, including a review of its need for currently solicited information. In CBO's view, both of these reforms would reduce construction permit delays.

Similar changes could be made in NRC's acceptance review, which it conducts to determine whether the utility's application, as submitted, contains sufficient information to merit docketing. Present policy is to docket an application if it contains at least 80 percent of the requisite information. By expanding the acceptance review from its present 30 to 60 days, subsequent time spent soliciting information from utilities could probably be reduced.

THE "FULL PUSH" APPROACH

Proponents of a full push to nuclear power argue that the present institutional structure of the licensing process no longer conforms to the realities of and the needs for nuclear power. These proponents point to the licensing procedure used in Western Europe, where the interior ministries and nationalized utilities cooperate in the licensing procedure, with limited access on the part of the public. A "full push" example of reactor licensing in the United States would operate as follows:

- The NRC would be confined to issues of radiological safety. Licensing itself would be carried out by the Department of Energy (DOE), where the Atomic Safety Licensing Board (ASLB) of the Atomic Safety Licensing Appeals Board would be located;

- Only complete construction permit applications would be docketed. Upon receipt of a complete application, the NRC staff would hold public meetings with the utility, which would replace the current two rounds of questions and answers. A safety evaluation report would then be immediately released;

- NRC would refrain from analyzing need for power and selection among alternative energy sites in its review, remanding these issues to the states. Since the 1971 Calvert Cliffs Coordinating Committee Inc. v. AEC 2/ decision, every proposed plant must be weighed on a cost-benefit basis against a group of theoretical alternatives using different fuels at different sites. Although the utility's decision to build a nuclear reactor at a specific site reflects such a weighing of alternatives, the review mandated by the court's interpretation of NEPA includes the costs of environmental damage (through radiation, thermal discharge, and so forth), and secondary benefits, such as tax receipts of local government, new jobs created and ensuing multiplier effects, and the like. This procedure would be eliminated through statutory

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2/ 449 F. 2d 1109, D.C.C.A. 1971.

revision, and the judgment of state officials concerning need for power and selection among energy alternatives would be final;

- Hearings before the ASLB, within DOE, would be held only at the construction permit stage, as in the case of one-stop licensing (discussed in Chapter IV). Contested hearings would be held only if intervenors presented prima facie evidence of a factual discrepancy with NRC staff reports. Questioning would be done only by hearings offices, although intervenors could provide lists of suggested questions to the officers involved. Final appeals would be to the Office of the Secretary of Energy;

- Finally, and, in the eyes of the nuclear industry, perhaps most importantly, the NRC would abandon the present moving standard of "as safe as practicable" in favor of an approach that could be termed "as safe as economics permits." Using this latter standard, the NRC would institute *a* set of standardized designs that were deemed "safe" for both the nuclear steam supply system and the balance of plant. These designs would receive a final design approval and would be immediately available for reference for a period of five years. Any revision in these designs would be approved only if their value in terms of additional safety could be justified when weighed against their costs, as is now the case in other industries.

Reforms of this kind could save up to a year in the licensing process. Because of the standard two rounds of NRC staff questions and utility responses, the period of time between docketing of a license for a construction permit and issuance of a staff safety report is frequently between 12 and 18 months. This time could be reduced to six months. Such a procedure would, however, require the provision of more information to the NRC by utilities. As discussed earlier in this chapter, although the licensing process would be shortened by better information, the preparation of more detailed applications would require more time and more money on the part of the utility. Although utilities often believe that the more data provided NRC, the longer the delays NRC will impose, through questions and mandatory design changes, on balance, it is likely that tendering complete applications would expedite the licensing process.

Further reforms of the hearing procedure would save several months. Yet doing so would severely limit public participation, insofar as intervenors generally do not often have sufficient resources to make prima facie factual challenges; hence they usually rely on a matter of interpretation of existing facts to force issues to a hearing. In addition, proponents of intervention consider discussions of interpretation of effects as one of the basic reasons for public **participation--that** is, the current role of the public is, in part, to give their view of what the facts mean.

Proponents of the full push scenario, however, point out that public participation was originally intended to educate the public more than to allow public input. Partly as a response to the precipitous licensing of the Fermi I reactor at Detroit in 1956, the AEC instituted mandatory hearings soon thereafter. As public opposition to, and militancy concerning, nuclear power grew, the hearing procedure became an adjucticatory battleground. Full push proponents see the present hearing procedure as forcing intervenors to use issues regarding a particular plant to accomplish a divergent **end—questioning** current U.S. nuclear energy policy. In such a situation, they argue, hearings can have only a limited productive use.

The final resolution of this question is a political matter that rests with the Congress and the President; ultimately, only they can define the role of public participation in decisions regarding centralized technology and concentrated economic power.

The nature of the National Environment Policy Act review poses a different question. It is unclear that the all-inclusive analysis of costs and benefits now conducted under the present interpretation of NEPA would be carried out in its absence, and such a calculation is important in evaluating a project of the size of a reactor project, and one with as many external effects. On the other hand, however, an analysis of this kind does create overlapping data requirements among agencies, and introduces redundancy into the licensing process. Nevertheless, ways could be found to expedite these calculations, within a context that will guarantee that an overview of social costs and benefits would be conducted. A possible solution could lie in the use of NRC approval of state review programs, as proposed in the NSLA, or in a redefinition of the intent of NEPA by the Congress.

APPENDIXES

APPENDIX A. DURATION OF PHASES IN NUCLEAR REACTOR LICENSING

Table A-1 presents historical statistics for various phases of the licensing process. The columns of this table, from left to right, conform to the usual sequence of events in the licensing phase of reactor lead times; environmental reviews, which may, if approved, lead to limited work authorization; safety reviews leading to construction permits; and the actual start of construction (which often precedes the issuance of a construction permit if a utility has requested work authorization). It should be noted that the data for 1976 and 1977 are NRC projections, hence these target lead times may be revised.

The data reveal a trend to longer lead times in most aspects of the licensing process when compared with the one-year reviews of the 1960s. The lead times for 1970 and 1971 are particularly long for two reasons; first, the Calvert Cliffs Coordinating Committee Inc. vs. A.E.C. case was litigated and a decision rendered in this period, and the decision forced a recalculation of the costs and benefits of reactors, the major component of environmental review. The four reactors in the Harris project, which announced major deferrals because of slackening electricity demand, are also included in 1971. These deferrals led to a postponement of the reactors' safety review, yielding the six-year review cited for the delayed group in 1971. After 1971, however, environmental reviews show considerable stability.

Safety reviews have expanded, and so has the length of time between safety review and construction permit issuance. The time between the two reflects review by the Advisory Committee on Reactor Safeguards, public hearings, delay in data transmission between the NRC and other agencies. Longer safety reviews reflect difficulties in the resolution of regulating issues, particularly core cooling systems and containments.

The data for the start of construction reveal that limited work authorizations have been successful in advancing construction by allowing site preparation before construction permit issuance. For each year observed, the start of construction preceded actual permit issuance.

TABLE A-1. AVERAGE DURATION OF VARIOUS PHASES IN NUCLEAR REACTOR LICENSING, BY YEAR OF NUCLEAR REGULATORY COMMISSION'S (NRC) ACCEPTANCE OF CONSTRUCTION PERMIT APPLICATION: IN MONTHS a/

Calendar Year	Construction Permit Applications Accepted by NRC	Environmental Review	Limited Work Authorization b/	Safety Review	Construction Permit Issuance	Start of Construction
1970	18	24.2 (18)	39.9 (1)	26.4 (18)	37.5 (18)	31.3 (18)
1971	12	22.6 (12)	___	38.5 (12)	41.7 (12)	42.2 (12)
Not Delayed	8	18.5 (8)	___	38.5 (12)	24.5 (8)	25.0 (8)
Delayed	4	30.7 (4)	___	72.1 (4)	76.0 (4)	76.6 (4)
1972	6	10.9 (6)	18.0 (4)	17.0 (6)	22.4 (6)	19.1 (6)
Not Delayed	4	9.7 (4)	17.5 (2)	18.0 (4)	16.2 (4)	19.4 (4)
Delayed	2	13.3 (2)	18.6 (2)	14.8 (2)	34.0 (2)	18.6 (2)
1973	32	13.9 (32)	17.6 (22)	23.9 (32)	31.1 (32)	20.7 (32)
Not Delayed	16	11.9 (15)	17.5 (16)	23.0 (16)	28.5 (16)	17.5 (16)
Delayed	9	15.7 (16)	17.8 (6)	25.0 (12)	35.6 (9)	26.4 (9)
Open	7	___ (1)	___	___ (5)	___ (7)	___ (7)
1974	40	13.9 (40)	18.4 (19)	29.0 (40)	35.9 (40)	27.9 (40)
Not Delayed	13	9.4 (13)	18.9 (10)	21.6 (13)	26.7 (13)	19.0 (13)
Delayed c/	15	17.3 (17)	17.8 (9)	34.7 (17)	43.7 (15)	35.6 (15)
Open	12	___ (10)	___	___ (10)	___ (12)	___ (12)
1975	9	14.6 (9)	24.9 (4)	29.4 (9)	38.3 (9)	32.8 (9)
Not Delayed c/	4	14.7 (5)	24.9 (4)	24.3 (4)	35.0 (4)	24.9 (4)
Delayed c/	2	14.3 (3)	___	39.5 (2)	45.0 (2)	48.6 (2)
Open	3	___ (1)	___	___ (3)	___ (3)	___ (3)
1976 c/	7	17.6 (7)	21.4 (5)	22.2 (7)	28.3 (7)	24.6 (7)
1977 c/	4	13.4 (4)	18.8 (4)	16.8 (4)	15.5 (4)	18.8 (4)

SOURCE: Nuclear Regulatory Commission.

NOTES: Numbers in parenthesis refer to number of reactors for which averages were calculated. Each year, utilities may inform the NRC that some reactors have been "delayed" or are "open." "Delayed" nuclear plants are those postponed by a utility; "open" plants are those with open-ended deferrals.

a/ As of January 31, 1978.

b/ Not all applicants pursue LWAs; hence annual total will be less than those of other categories.

c/ Includes projected data.

APPENDIX B. CALCULATION OF COSTS OF DELAY IN REACTOR LEAD TIMES

CBO has estimated that the cost of a month's delay in reactor lead time is $8.9 million before construction permit issuance, and $10.6 million for reactors undergoing construction (see Table B-1). The way in which these costs were calculated are described below:

TABLE B-l. COSTS OF A MONTH'S DELAY IN LICENSING AND CONSTRUCTION OF A 1,100 MEGAWATT REACTOR, ANTICIPATED ON LINE IN 1987: IN THOUSANDS OF DOLLARS

Type of Cost	Before Construction Permit	After Construction Permit
Energy Replacement	2,518	2,518
Inflation	6,105	2,677
Interest	250	5,393
Total	8,873	10,588

Energy Replacement

To calculate energy replacement costs, CBO assumed that in the absence of a completed reactor, electricity is produced by extending the life of oil-burning facilities beyond their anticipated use. Thus, the costs incurred because of the need to provide replacement energy are the costs of oil burned and the cost of operation and maintainance (O/M) of the old, oil-burning unit. CBO also assumed that no capital charges are allocated to the oil-burning facility, since it has already been employed for its anticipated life and thus has already repaid its costs of construction. Such a facility would, however, require greater than normal O/M costs because of its advanced age. To obtain the incremental costs of providing replacement energy, the costs of reactor operation must be subtracted from the costs of fuel oil, plus advance O/M costs of the oil-burning facility. Estimates of reactor costs for this section were taken from Ebasco Services, Inc. 1/

The costs associated with oil-based replacement energy are twofold. 2/ Fuel costs are derived from the price of crude oil. Operation and maintenance costs vary over the life cycle of an oil-fired boiler. Because several different values could be assumed for the price of crude oil, and several different assumptions for the level of O/M, these costs are assumed, alternatively, to be two, three, or four times the normal level of those costs. The price of crude oil is assumed to rise at a zero, 2, or 3.5 percent rate of real increase. The assumptions yield different estimates of fuel replacement costs (see Table B-2). Assuming the middle case for both—a steady 2 percent real increase in the price of crude oil between now and 1987 (yielding a price of $28.18 a barrel in 1987) and a triple allowance for O/M expenses—CBO estimates that the cost of energy replacement would be about $2.5 million per month of delay for an 1,100 megawatt reactor operating at 70 percent capacity (capacity now ranges between 60 and 65 percent). An equivalent figure is reached if replacement is assumed using "wheeled in" electricity supplied by coal-fired plants.

TABLE B-2. INCREMENTAL FUEL REPLACEMENT COSTS FOR A ONE-MONTH DELAY IN CONSTRUCTION OF A 1,100 MEGAWATT REACTOR: IN THOUSANDS OF DOLLARS

	Assumed Rate of Real Increase in Crude Oil Prices, 1976-1987		
Operating/Maintenance Costs of Oil-burning Unit	No Increase	2.0 Percent Increase	3.5 Percent Increase
Twice the Average Level of Operating/Maintenance Costs	0	922	4,789
Three Times the Average Level of Operating/Maintenance Costs	0	2,518	6,385
Four Times the Average Level of Operating/Maintenance Costs	0	4,115	7,981

1/ Ebasco Services, Inc., "Dramatic Changes in Nuclear and Fossil Costs" (New York, May 1977).

2/ See ICF Inc., "The National Coal Model-Description and Documentation" (Washington D.C., October 1976).

Inflation

Inflation is a delay cost because it affects the additional cost of the work that will be done after a delay is experienced. For example, if the current capital cost of an 1,100 megawatt reactor is $1.2 million per megawatt, and the project is 40 percent complete, then, if construction were fully stopped, the cost of a year's delay would be $1.2 million per megawatt times 1,100 megawatts, times 60 percent (the unfinished portion of the project), times the rate of inflation. An inflation rate of 7 percent was assumed. CBO estimated inflation costs as being $6.1 million per month before, and $2.7 per month after, construction permit issuance, when averaged. However, it should be noted that consumers will purchase electricity that reflects these inflation costs with inflated dollars, so that this need not represent a real resource loss.

Interest

Interest costs are the opposite of inflation costs, since they represent costs already incurred because of a delay in construction. To calculate interest costs, it is assumed that the utility borrows to meet cash expenditures as they occur over the life of the project. Using the example given above for inflation costs, the interest costs of a year's delay would be $1.2 million per megawatt times 1,100 megawatts, times 40 percent, times the rate of interest. Assuming a 9 percent rate of financing, interest costs are estimated as being $250,000 per month before construction permit issuance and $5.4 million per month during construction. Construction permit issuance is assumed to occur when 30 percent of the project time has been expended. (Estimates of the cash flow function for reactors were taken from ERDA.)

The final incidence of these costs is uncertain, and depends on the nature of utility regulation by the relevant state public utility commission. If the commission allows construction work in progress and increased interest payments in the rate base, then many of these costs will be reimbursed through tax treatment. Interest paid out during delays is deductable under present tax law, and each dollar spent in this category will only "cost" the utility $.52. Inflation in construction costs is later recouped, to some extent, through depreciation, but at a later point in time than tax savings from interest deductions, which are realized the next year.

APPENDIX C. REACTORS CITED IN REPORT

As of December 1978, there were 211 reactor projects in the United States either completed, under construction, under construction permit review, or at the planning stage.

Reactor	Utility	Location
Ano	Arkansas Power and Light	Pope County, Ark.
Browns Ferry	Tennessee Valley	Decatur, Ala.
Callaway	Union Electric	Fulton, Mo.
Calvert Cliffs	Baltimore Gas and Electric	Annapolis, Md.
Catawba	Duke Power	Charlotte, S.C.
Clinton	Illinois Power	Hart Township, Ill.
Diablo Canyon	Pacific Gas and Electric	San Luis Obispo, Calif.
Fermi	Detroit Edison	Detroit, Mich.
Indian Point	Consolidated Edison	Peekskill, N.Y.
LaSalle	Commonwealth Edison	LaSalle, Ill.
McGuire	Duke Power	Mecklenberg, N.C.
North Anna	Virginia Electric Power	Louisa, Va.
Pebble Springs	Portland General Electric	Arlington, Oreg.
Pilgrim	Boston Edison	Boston, Mass.
Palo Verde	Arizona Public Service	Wintersburg, Ariz.

River Bend	Gulf States Utilities	W. Felinciana Parish, La.
Seabrook	Public Service Company of New Hampshire	Seabrook, N.H.
Skagit	Puget Sound Power & Light	Sedro Wooley, Wash.
Sterling	Rochester Gas and Electric	Cayuga, N.Y.
Tyrone	Northern States Power	Dunn County, Wis.
Waterford	Louisana Power and Light	Taft, La.
Watts Barr	Tennessee Valley Authority	Spring City, Tenn.
Wolf Creek	Kansas Gas & Electric	Burlington, Kans.
Zimmer	Cincinnati Gas & Electric	Clermont, Ohio