Archive

COMPARATIVE ANALYSIS OF UNITED STATES AND FRENCH NUCLEAR POWER PLANT SITING AND CONSTRUCTION REGULATORY POLICIES AND THEIR ECONOMIC CONSEQUENCES

by

Michael W. Golay, Isi I. Saragossi and
Jean-Marc Willefert

Energy Laboratory Report No. MIT-EL 77-044-WP

December 1977

Working paper from the joint Nuclear Engineering Department/
Energy Laboratory Light Water Reactor project sponsored by
the U.S. Energy Research and Development Administration
(now Department of Energy)

COMPARATIVE ANALYSIS OF UNITED STATES AND FRENCH NUCLEAR POWER PLANT SITING AND CONSTRUCTION REGULATORY POLICIES AND THEIR ECONOMIC CONSEQUENCES

by

Michael W. Golay
Isi I. Saragossi
Jean-Marc Willefert

Energy Laboratory

and

Department of Nuclear Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Sponsored by

U.S. Energy Research and Development Administration
(Now Department of Energy)

Energy Laboratory Report No. MIT-EL 77-044-WP
December 1977

NOTICE

ABSTRACT

Despite the substantial commitments of time and money which are devoted to the nuclear power plant siting process, the effectiveness of the system in providing a balanced evaluation of the technical, environmental and public interest considerations is periodically questioned. Until now, all improvements in the siting process have introduced increased complexity and delays.

In order to approach this problem from a new point of view, it is interesting to evaluate U.S. siting and licensing processes in contrast with corresponding foreign policies. This work compares the American and French policies. Initially, the economic structures, procedures and regulations in both countries that determine the siting policies and procedures for nuclear power plants are examined. Then, the results of a survey of American utilities' practices concerning their licensing histories and delays that have affected U.S. nuclear power reactors since 1965 are analyzed.

It is found that although the French experience is more limited than the American one, French practices emphasize an attempt to shift consideration of major design issues in the early stages of the construction permit process, before major on-site construction commitments are made. Other important differences are that the French process is cooperative and flexible while the American process is adverserial, legalistic and rigid; and the French process allows for very little public

participation or review of regulatory decisions while the American process allows relatively easy participation of public and non-federal agencies in the licensing process and has the possibility for review of regulatory decisions at several administrative and judicial levels. Power station construction and operation delays are common in the United States experience and rare in the French experience.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

INTRODUCTION

This paper reports the results of a comparative analysis of United States and French nuclear power station licensing procedures and experience. The work consists of surveys U.S. and French nuclear utility experience and attitudes, interviews with personnel involved in important sectors of the nuclear power economies of each country, and examination of the procedures followed in each country in nuclear power station licensing.

It is seen that there are substantial differences in licensing procedures and experiences in the two countries which - to a degree - reflect basic differences between the societies in each country.

The French system is seen to be more efficient than the American, but also more authoritarian and unresponsive to criticism from outside the government. While it is impossible to be very accurate regarding the relative importance of possible causal factors which could cause delays in bringing a power plant on-line, it is clear that delays are expensive and that the American system offers many more potential sources of delay than the French. The basic purpose in pursuing this study has been to examine the degree to which the two systems result in different delay histories and to try to understand the reasons for the differences. The incentive to do this arises from a widely held perception that the American system has become so inefficient and unreliable as to be effectively inhibiting the use of nuclear power through mechanisms which basically have

little to do with the technology itself. The goal of this work is to examine the degree to which this perception is valid, and to identify means by which the system could be made more efficient if the need to do so is found to exist.

1. STRUCTURES OF THE POWER INDUSTRIES IN FRANCE AND THE U.S.

1.1 Structure of the Power Industry in France

1.1.1 The Nationalization Law of April 8, 1946.

On April 8, 1946, a Nationalization Law created two public companies in charge of Production, Transport and Distribution of Gas and Electricity: Gaz de France (G.D.F.) and Electricité de France (E.D.F.). Before this law, these functions were being assumed by many different companies. Consequently, the major part of the French electricity production today comes from E.D.F. (86%), the rest being produced by some industries for their own use (mines, steel, industry). Both E.D.F. and G.D.F. are subject to parliamental and governmental control but can be considered in many respects as independent industrial and commercial companies.

1.1.2 Structures of the E.D.F.

E.D.F. is organized in several independent sections:

- Power Production and Transmission (21,800 employees)
- Equipment (3,600 employees)
- Research (2,100 employees)
- Administration (6,800 employees)

E.D.F. shares with G.D.F. the Distribution Section (87,300 employees). The Power Production and Transmission Section is subdivided into:

- Thermal Power Production (10,500 employees)
- Hydraulic Power Production (5,000 employees)
- Energy Transmission (6,300 employees)

The Thermal Power Production Section is organized in eight regional groups. In 1975, it counted 40 power plants (each having a variable number of units) as follows:

- Some low-power units and gas turbines
- One 75 MWe gas turbine
- 38 (125 MWe) fossil units
- 37 (250 MWe) fossil units
- 7 (600 MWe) fossil units
- 9 nuclear units (for a total of 2,500 MWe)
- 4 (700 MWe) fossil units in construction
- 20 (900 MWe) nuclear units in construction

Figure 1.1 gives the geographical distribution of the power plants operated or in construction as of January 1, 1976.

1.1.3 Energy Sources for Electric Power Production in France.

The 1976 total energy consumption was approximately equal to 850 TWhr (1 TWhr = 10^9 KWhr) of which 23% came from electric power consumption.

The hydroelectric production was about 60 TWhr. The evolution of fuel distribution for thermal power production from E.D.F. is given in Figure 1.2; the detail for fossil fuels is given in Figure 1.3.

At the time of the Nationalization Law, electricity was produced almost exclusively from coal. It is seen that some diversification occurred later, until 1970 when the electric energy produced from oil equaled that produced from coal. Then the share of coal continued decreasing while the share of oil was increasing.

Most of the oil for electric power production is imported. The tendency to rely on oil as a fuel began to be reversed in 1973 after the substantial changes in international oil markets at that time; it can be seen that the share of coal increased again after 1974.

The share of nuclear energy began increasing in 1972. Beyond the 9 nuclear units actually operated, 20 nuclear units are in construction on eight sites (18.5×10^6 KWe) and 50 additional units of 1000 MWe on 12 sites are planned to cover most of the increase in electricity production after 1978.

Table 1.1 shows the evolution of energy sources utilization for electric power production in France.

One forecast of the French energy consumption is given on Figure 1.4. The strong shift towards nuclear energy is clearly evident.

1.2 Structure of the Power Industry in the U.S.A.

1.2.1 Private and non-private utilities.

The electric power industry in the U.S. is made up of essentially three types of utility systems:

- Private investor owned utility systems,
- Cooperative systems owned by communities, companies or users,
- Public non-profit systems owned by state utilities, public utility districts and state power authorities or by federal agencies.

There are approximately 3500 enterprises of the three categories for production, transmission and distribution of electricity. The total U.S. generating capacity as a function of ownership is shown in Table 1.2. The structure of the U.S. electric power industry is given in Figure 1.5.

As indicated in Table 1.2, most of the generating capacity comes from investor-owned systems and the same percentage applies for transmission and distribution.

The financial dealings of investor-owned utilities are closely regulated by the Federal Securities and Exchange Commission and the state of the power industry is periodically surveyed by the Federal Power Commission (now absorbed into the Department of Energy). At the state level, the Public Utilities Commissions have the responsibility for negotiating the utilities' franchises. The franchise agreements, peculiar to each state, determine the utility's rate structure, the specific rate of return on investment, and its right to construct distribution facilities within its territory. Each utility has a monopoly on electric service within its franchise area, but because of reliability of supply considerations and economic and regulatory pressures, the utilities are often organized in large regional networks (see Figures 1.6 and 1.7). This power pooling allows electricity production and distribution on a regional interstate basis and it involves planning, operation and coordination of supply. Most of the large nuclear plants are consequently owned by several investor-owned or public utilities.

1.2.2 Energy Sources for Electric Power Production in the U.S.

Coal remains today the major energy source for electric power production in the U.S. Though in the past the share of oil and gas have been regularly increasing, these fuels are currently experiencing a saturation effect due to the partial depletion of domestic resources and increasing prices (see Figure 1.8), as well as federal prohibitions on their use.

Consequently, a significant development of both nuclear and coal fired plants is expected for the next years; the relative importance of each category being actually discussed remains very uncertain.

As of December 31, 1977, there were in the U.S.:

- 60 Nuclear units in operation with a total capacity of 42,000 MWe,
- 86 nuclear units in construction with a total capacity of 87,000 MWe,
- 56 nuclear units under review for construction permits with a capacity of 63,000 MWe.

Figure 1.9 shows the current approximate geographical distribution of fuel utilization for electric generation, nuclear fuel excepted. Figure 1.10 shows the potential nuclear electric power regions. Depending upon the energy growth rate, Table 1.3 gives the number of sites required to meet demand.

1.3 Conclusion

The electric energy consumption in France and in the U.S. represent respectively 23% and 27% of the total energy demand. Thus, the amounts of electrical energy produced are very different in each country: 2000 TWhr in the U.S. and 180 TWhr in France in 1975. But, if 77% of the U.S. generating capacity is distributed over about 250 investor-owned utilities, 86% of the French generating capacity is concentrated in one public company, whose size is then comparable with that of the biggest U.S. utilities (in 1970, E.D.F. produced 58 TWhr of non-hydraulic energy, while the biggest U.W. utility, American Electric Power, produced 60 TWhr).

Both industries are now considering the use of nuclear power to meet future energy demands, and are confronted with the problem of siting large nuclear power plants (the future French nuclear units will mostly be 975 MWe PWR units very similar to the Westinghouse U.S. plants - the prototype is the Bever Valley station). But it should be noted that the French electric power industry has recently experienced a large change of energy source from coal to imported oil (see Figure 1.2) while the U.S. industry has been mostly depending on domestic coal, gas, and oil (see Figure 1.8). Then, in the short range, the alternatives for base load production in France are reduced to use of more imported oil or nuclear power. In the U.S., the issue must be considered taking into account the existence of domestic fossil resources (mainly coal) that can still be of significant importance for the next century.

Table 1.1: Electric Power Production in France as a Function of Fuel

Fuel \ Time	1965	1973	1975
Coal	62%	14%	19%
Oil	27%	63%	51%
Gas	8%	10%	12%
Nuclear	3%	13%	18%

Table 1.2: Total U.S. Generating Capacity as a Function of Ownership.

Investor-owned Systems	Federal	Public Non-federal	Cooperatives
77%	1%	9%	2%

Table 1.3: Projection of Sites Required in the U.S. to Meet Demand.

Annual Demand Growth Rate (%)	Cumulative New Sites 1984 - 2000 (2300 MWe/Site)
3	129
4	205
5	314
6	442

	OPERATED	IN CONSTRUCTION
FOSSIL-FUELED	●	○
NUCLEAR	■	□
GAS-TURBINES	▲	△

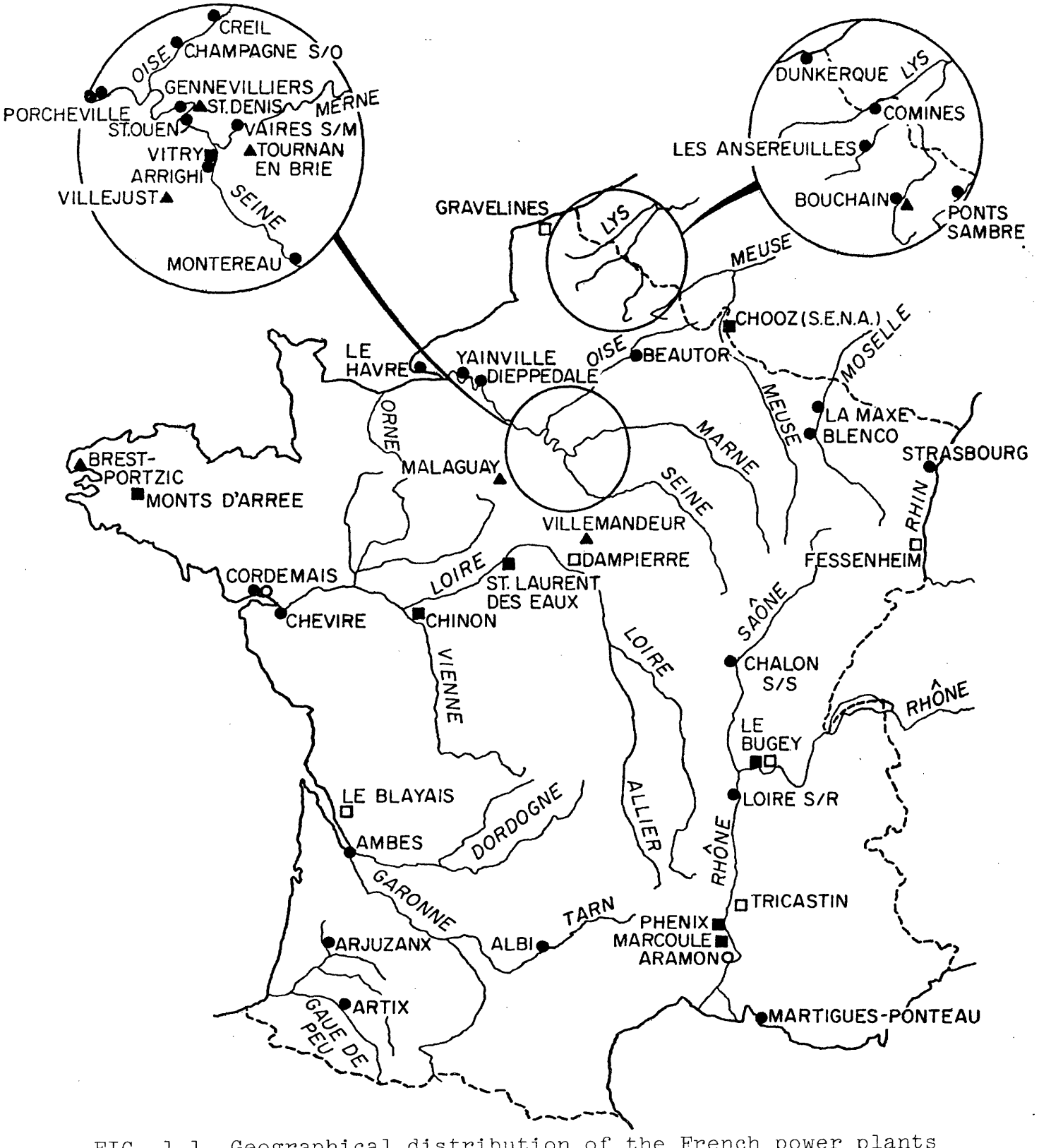


FIG. 1.1 Geographical distribution of the French power plants operated or in construction on January 1, 1976.

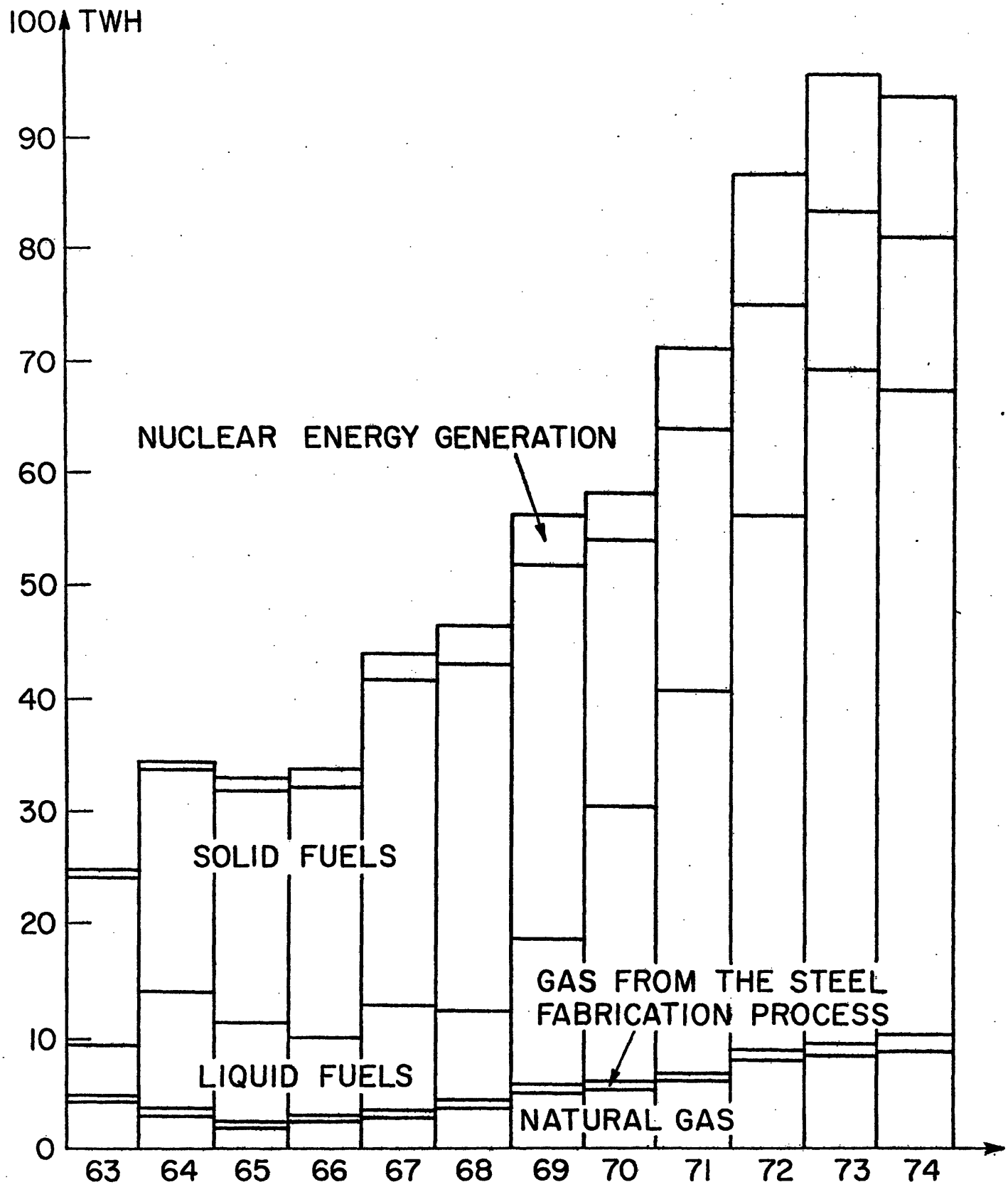


FIG. 1.2 Evolution of fuel distribution for thermal power production at EDF

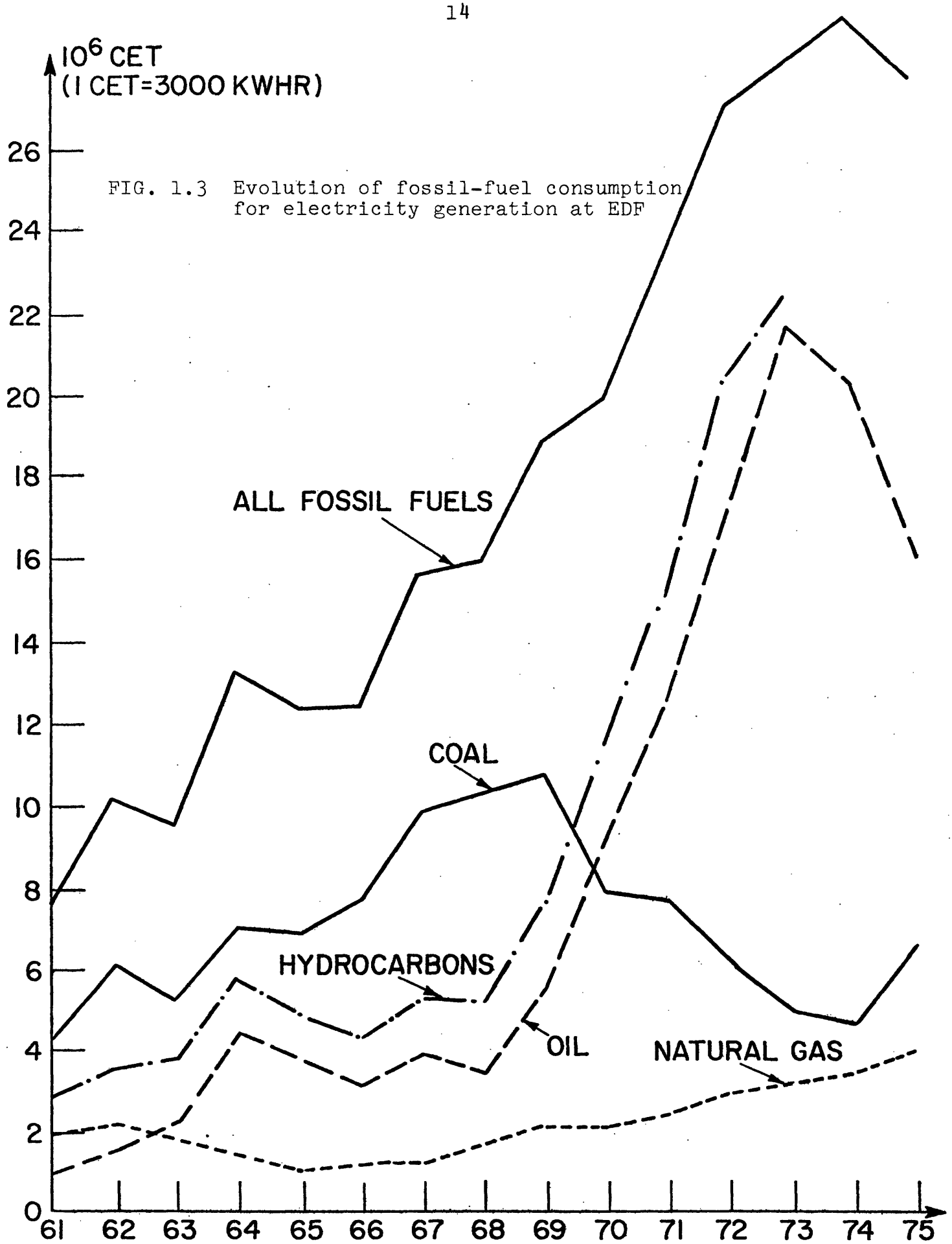


FIG. 1.3 Evolution of fossil-fuel consumption for electricity generation at EDF

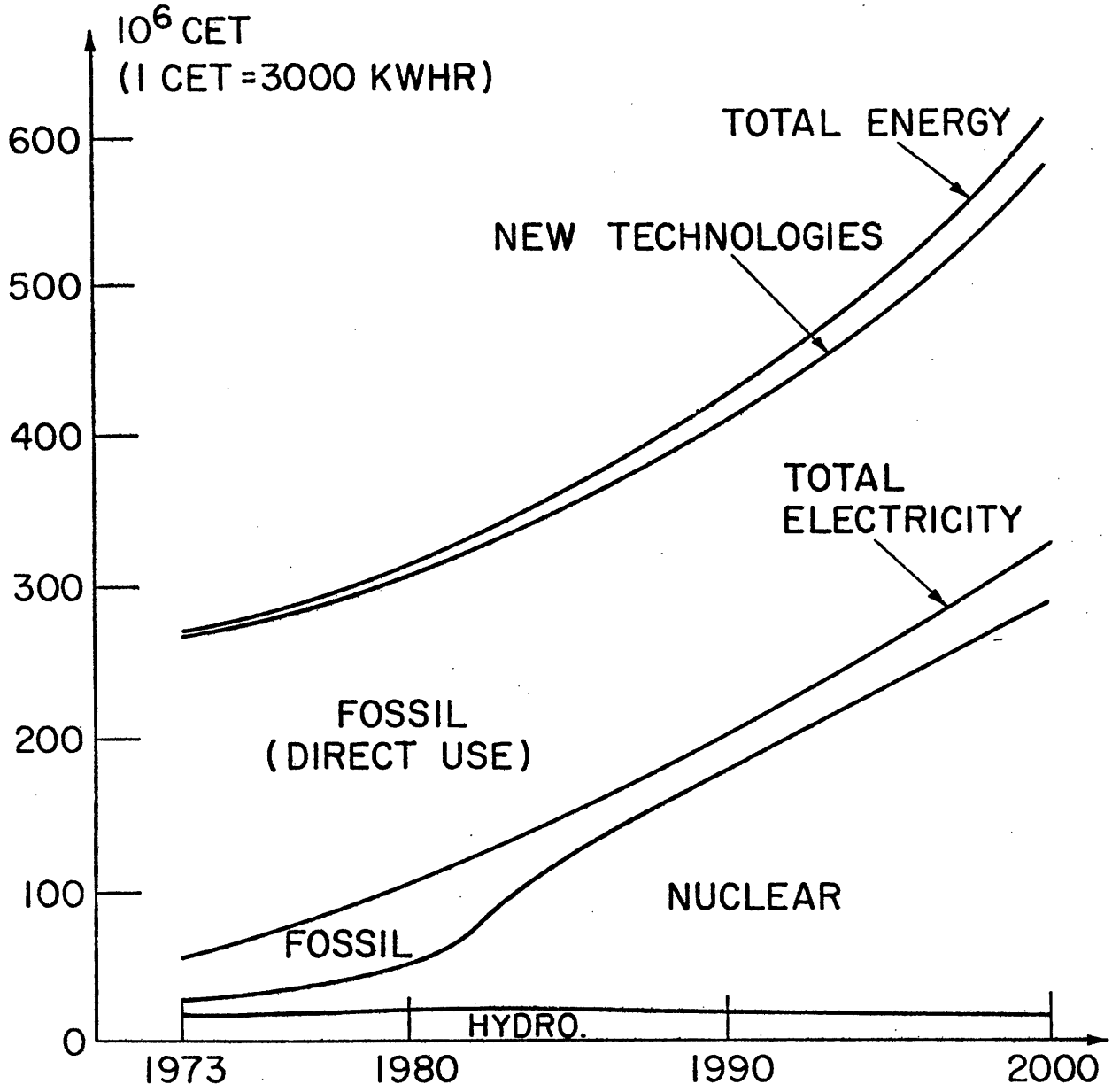


FIG. 1.4 French energy consumption forecast (1973)

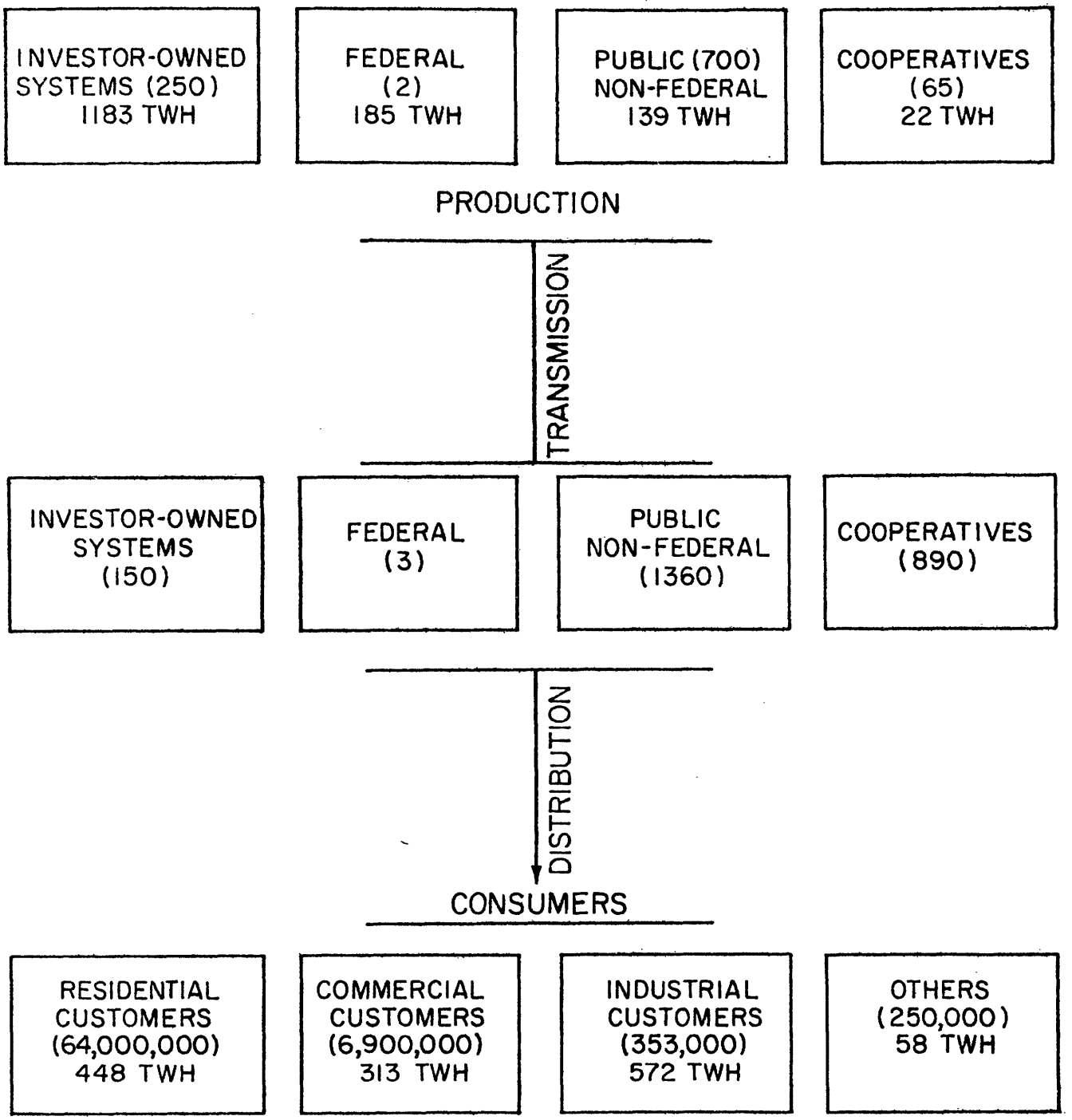


FIG. 1.5 Structure of the electric power industry in the U.S. in 1970

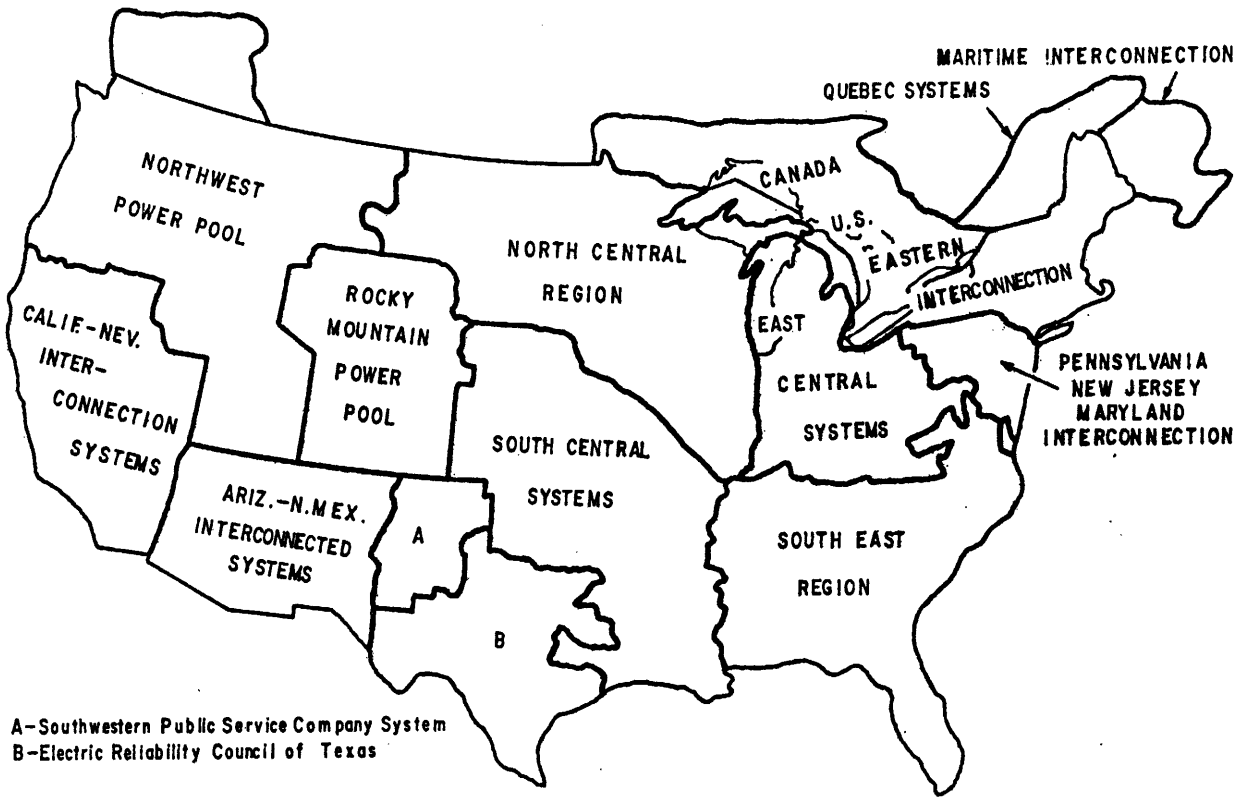
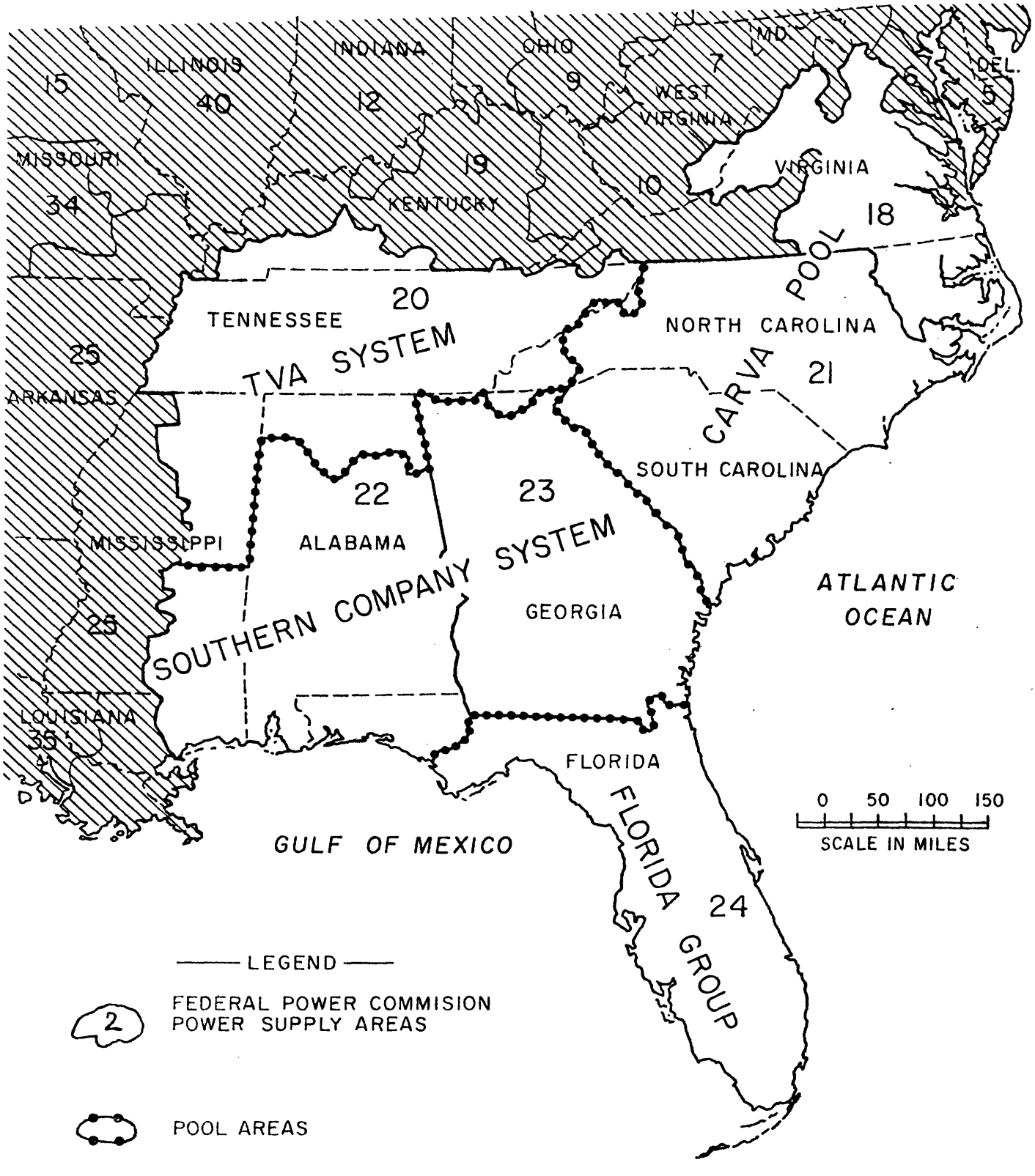


FIG. 1.6 North American Power Systems Interconnection Committee Areas

FIG. 1.7 Power supply area and power pools



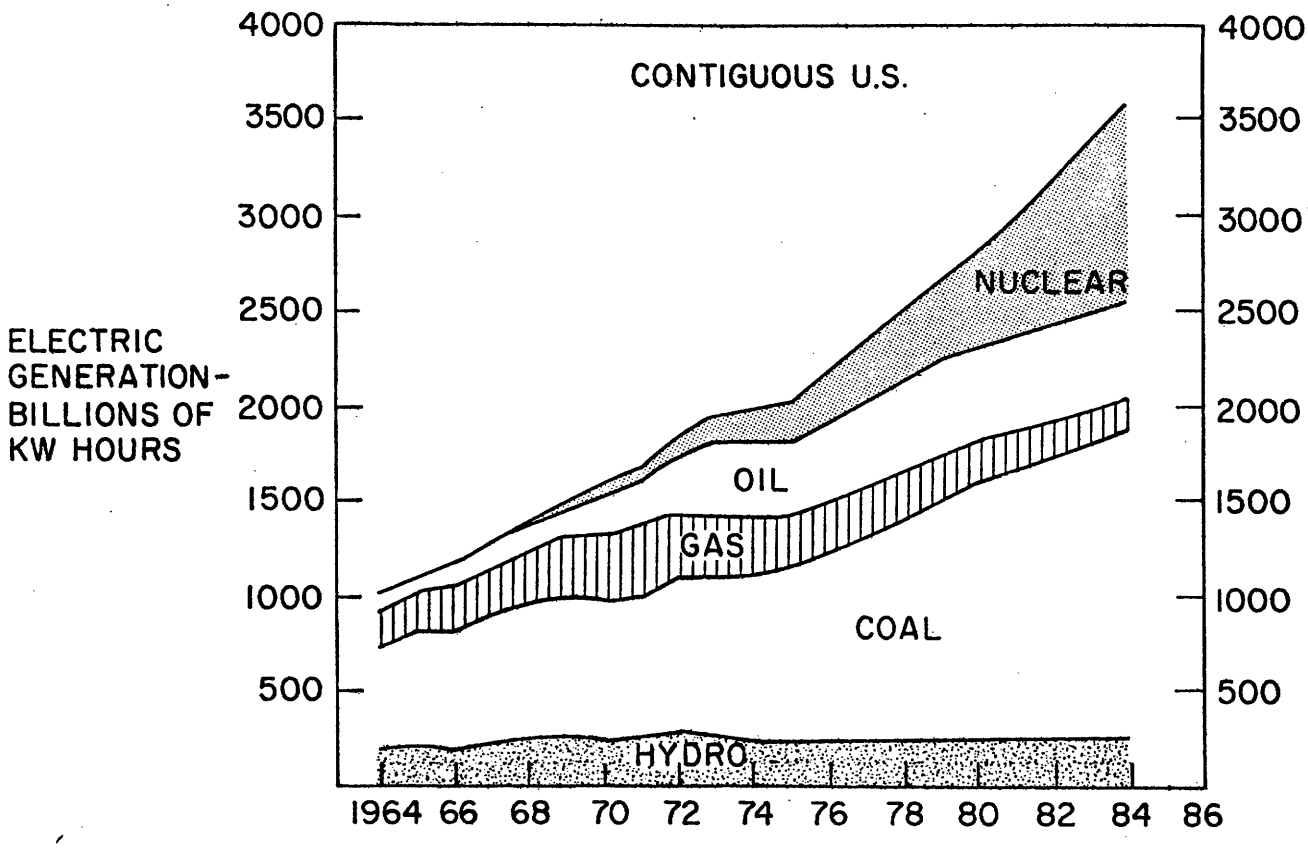


FIG. 1.8 U.S. electric generation by principal sources

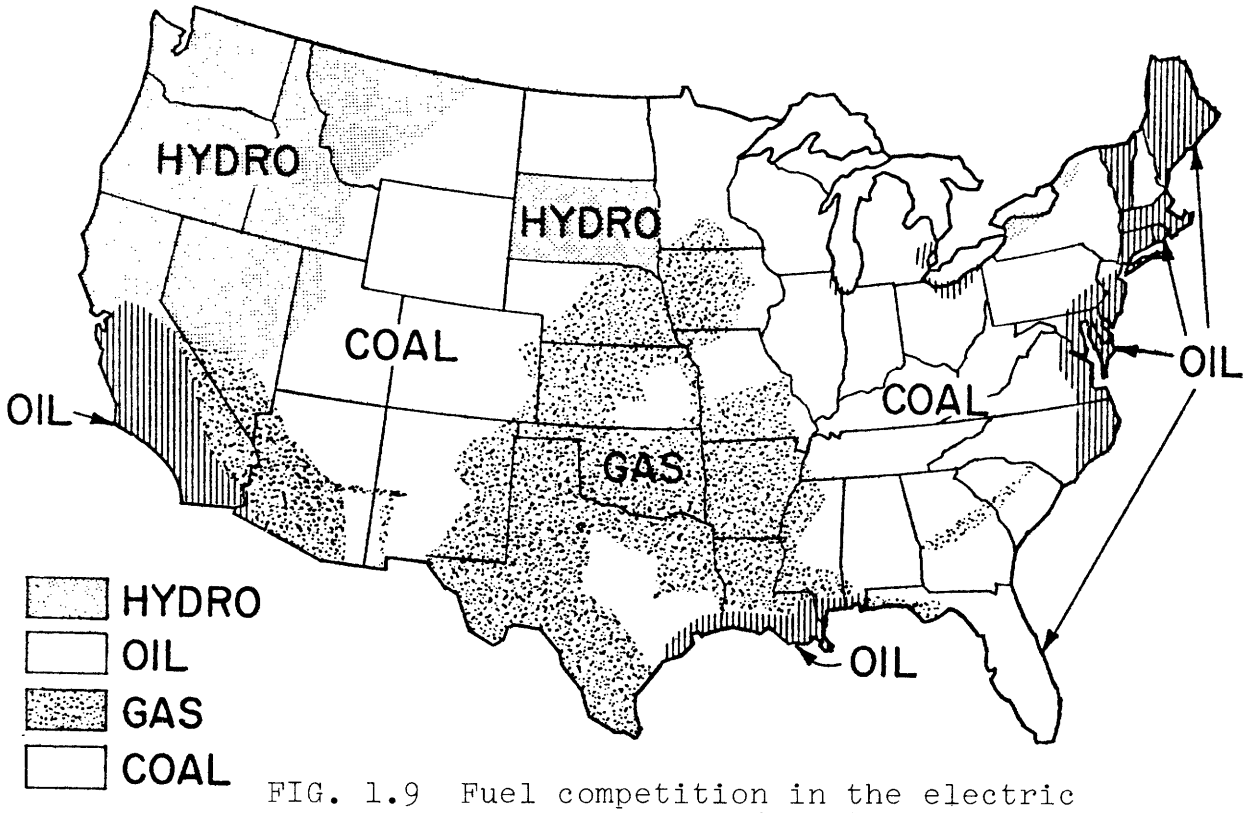


FIG. 1.9 Fuel competition in the electric power industry (1973)

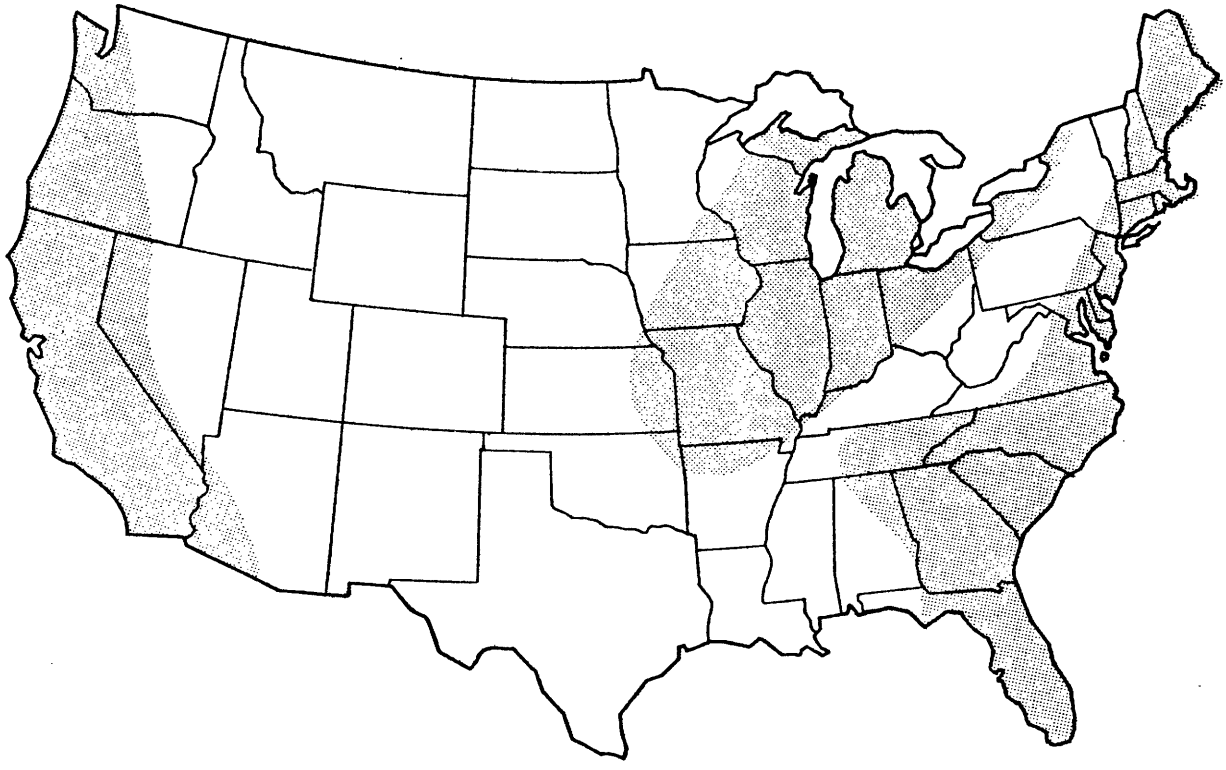


FIG. 1.10 Potential nuclear electric power regions in 1990

2. FRENCH SITING AND LICENSING PROCEDURES

2.1 Creation and Evolution of the French Nuclear Program

French nuclear policy is determined by the Government of the Republic in terms of nuclear capacity to be installed over certain periods.

Govenmental decisions concerning nuclear development are generally initiated by the recommendation of the "PEON" Commission (Comission pour la Production d'Energie d'Origine Nucléaire, a consultative body created in June 1967 by the French government to study the number and type of nuclear power plants to build to satisfy the energy needs of the country, taking into account its industrial capacity). The Commission is a consultative body of thirty-six members, reporting to the Ministry of Industry and Research; three of its members are from the Government-owned national public utility, Electricité de France (E.D.F.). The history of this planning procedure can be summarized as follows (1).

- 1968: E.D.F. decides to abandon the natural uranium gas graphite reactors. From 1959 to 1972, eight commercial plants of the gas cooled type (GCR) have been commissioned for a total capacity of 2,275 MWe, one of these being a gas-cooled heavy-water-moderated reactor (GCHWR) (see Table 2.1).
- November, 1969: The Select Committee decides to launch a light-water reactor program from 1970 with Fessenheim 1.

- 1970: In addition to Fessenheim 1, the PEON Commission recommends the construction of at least 8,000 MWe of LWR capacity in the course of the VIe Plan.
- 1973: The PEON Commission recommends that, in addition, 13,000 MWe of LWR capacity should be commissioned in five years from 1978 to 1982 and that a 1200 MWe FBR should be undertaken in 1974.

These recommendations were confirmed by the commitments made for Fessenheim 1 (1970), Bugey 2 (1971), Fessenheim 2 and Bugey 3 (1972), Saint-Laurent-des-Eaux B1 and Bugey 4 (1973).

Although an acceleration of the nuclear program had already been planned in the autumn of 1973 (just before the outbreak of the Arab-Israeli war), it was planned, at the beginning of 1974, that the rate of construction of nuclear capacity could not practically be increased beyond 7 GWe per year, indicating that an optimal mix of nuclear and fossil generation could not be reached before 1985. Moreover, to maximize the NSSS production capacity of French industry, it was decided to rely on strict standardization and mass production procedures.

These considerations motivated the following decisions:

- March 5, 1974: The French Government decided to undertake 13 LWR units of 900 to 1000 MWe capacity during the years 1974 to 1975;
- The Planning Council of January-February 1975 and the Select Committee of August 6, 1975 decided to:

  - Abandon BWR's
  - Begin construction of 12 GWe of PWR's in 1976-77, and
  - Begin construction of the first 1300 MWe PWR in 1976;
- At the same time, the French Government requested that the Commissariat à l'Energie Atomique (CEA), the national agency in charge of nuclear R&D, should increase its share in Framatome, the industrial group by which the PWR's ordered by E.D.F. would be exclusively manufactured. One of the purposes of this action was to prepare for a transformation of the licensor-licensee relationship between the U.S. Westinghouse Electric Co. and Framatome to one of partnership (3). The negotiations with Westinghouse resulted in 1975 in a decrease in Westinghouse holdings and takeover of 30% of total shares by CEA (see Figure 2.1).
- April 15, 1976: The Planning Council confirmed the commitment to 12 GWe for 1976-77, five GWe for 1978, and the continuation of the Fast Breeder Program with Super-Phenix.

Consequently, in April 1974, E.D.F. settled with Framatome, the industrial group by which the PWR's will be exclusively manufactured, a first batch of grouped orders (Multiannual contract No. 1) of sixteen identical, 925 MWe Nuclear Steam Supply Systems (NSSS) whose construction startup dates were spread from 1974 to 1976. The second batch of grouped orders of February 1976 (Multiannual contract No. 2) consists of 10 identical, 925 MWe NSSS's -

six of which are in option. Beginning of construction of the first unit is planned for 1977. The third multiannual contract of January 1976 includes eight 1300 MWE NSSS's, four of which are in option; staggered production dates start in mid-1977. Multiannual contract No. 1 covers the 1974 program; Multiannual contracts No. 2 and 3 cover the 1976 program (see Table 2.1).

In order to meet these requirements of nuclear capacity expansion, E.D.F. had to cope with the problem of finding acceptable sites for large nuclear power plants. In 1974, 20 units (18.5 GWe) were in construction or planned for the near future on eight sites for commissioning before 1980, and 12 sites had to be chosen for a capacity of 50 GWe for commissioning between 1980 and 1988 (4).

Since 1974, the sites at Paluel, Gravelines, Tricastin, Bugey and Blayais have been declared as being of "Public Utility Status". Procedures are taking place for obtaining the sites of Flamanville, Saint-Maurice l'Exile, Cruas, Cattenom, Pellerin, Nogent, Creys and Chinon.

2.2 Emphasis on Preliminary Studies and Early Stages of Site Selection

Electricité de France being responsible for electricity production, transmission and distribution over the entire area of France, is in a favorable situation to adopt a broad viewpoint on nuclear power plant siting problems.

Its size and resources also allow it to undertake studies independent of any immediate particular power plant project - such as the creation of a site inventory. Therefore, the early stages of site selection can rely on nationwide studies.

In the field of environmental impact of nuclear power plants, the following types of studies are pursued:

- A study of thermal dilution capacilities, and main hydro-biological and ecological characteristics of the river Rhône and of the entire French coast on the North Sea, the English Channel, the Atlantic Ocean and the Mediterranean Sea (5),
- A study of the ecological impacts of nuclear power plants with once-through cooling (6),
- A study of ecological impacts of the utilization of chlorine for plants on shore or in estuaries (7),
- Experiments to test beneficial uses of the thermal discharges of nuclear power plants (8),
- Studies of nuclear site selection with respect to dilution capabilities and comparison of various national strategies considering the other constraints (9),
- Studies of radiological release impacts (10),
- Studies of noise impacts (11) and aesthetic impacts (12),
- Studies of meteorological and air pollution impact (13).

The French licensing process is characteristic of the wish of the national authorities to be able to have an efficient and flexible program regarding the choice and design of potential power plant sites as early as possible, when choices regarding sites still have limited economic consequences (14).

The main steps in the individual plant siting process are indicated in Table 2.2, N being the year of beginning of operation.

It can be seen that the process involves contacts with local authorities and the public as early as the first year of the site selection studies. These early contacts do not follow a strict institutionalized pattern, and have been enforced by governmental authorities' direction of E.D.F. actions. These contacts include informal discussions at all levels, from that of the private citizen to the level of the governmental licensing administrations. Local authorities and representatives can propose at this stage alternative sites to be selected for draft studies. Examples are also available of changes in site location and plant design obtained at this stage; for instance, the change in the location of the Fessenheim plant because of seismic considerations, required design of an antimissile wall at the same plant, and required design of supplementary liquid effluent tanks (15). The fact that E.D.F. is the only utility involved in the siting of nuclear power plants eases such informal contacts (15).

In 1974, the opinion of local representatives was solicited regarding 37 potential sites with a goal of selecting 12 sites for use in the early stages of the nuclear program. Such local-level contacts are continued through the stage of the Draft Studies (see the content of the Preliminary and Draft Studies in Tables 2.3 and 2.4).

Following these contacts with local authorities, which began in 1974, a notable result was the replacement of the site at Manvieux in Normandy by that at Englesqueville at the suggestion of local (prefect-level) governmental representatives. In addition, the site at Arras on the Rhône river was rejected, and environmental studies at the Belleville-sur-Loire site were begun in order to address concerns at the local level.

2.3 The "Public Utility Status" Procedure

When a particular site is selected by E.D.F., the official procedures of the application for "Public Utility Status" and Construction Permit are launched. The "Public Utility Status" gives E.D.F. the right of Eminent Domain over the land of the site, but also represents the official recognition of the status of the project as a national effort. The "Public Inquiry" which is conducted as part of the review of this application is also used as a vehicle of public information and participation, and its results are used as one element of the Construction Permit review (see Figures 2.3 and 2.4).

The "Public Utility Status" application is submitted by E.D.F. to the Ministry of Industry and Research (MIR) - Section Gas, Electricity and Coal (GEC) - and most of the subsequent licensing steps are supervised by the Interdepartmental Service of Industry and Mines (ISIM) as shown in Figures 2.2 and 2.3.

The "Public Utility Status" application is first reviewed by all concerned administrative agencies, and then the Minister of Industry and Research decides whether the need for

the project justifies the continuation of the review to the "Public Inquiry" stages. This first stage lasts approximately six months. If its results are favorable, E.D.F. generally submits a Construction Permit Application and starts on-site preparation work and early construction with the authorization of the Ministry of Industry and Research. The "Public Inquiry" provides official information to the public at the City Halls of the cities in the region of the site. Official local authorities have the responsibility of providing this information. All questions, suggestions, and comments of the public are also recorded by designated commissions at the same places.

The "Public Inquiry" can last from 15 days to two months. After the end of the Public Inquiry, E.D.F. has three months to answer the questions raised by the inquiry, and during that period private citizens directly concerned with the project receive personal answers. E.D.F. also has to answer additional questions from the Official Agencies which had not been asked in the first stage of the procedure.

Considering comments of the Public Inquiry Commission and all concerned agencies, the Prime Minister decides whether to confer the Public Utility Status to the project (17).

2.4 Construction Permit Procedure

If the first results of the Public Utility Status procedure are favorable, E.D.F. submits a construction permit application to the Ministry of Industry and Research. The Service for

Nuclear Safety (Service Central de Sureté des Installations Nucléaires) supervises the steps of the procedure as shown in Figure 2.4. This group is responsible for proposing the technical specifications or recommendations of the government or the Minister at each step (18).

The review of the Preliminary Safety Report, submitted by E.D.F., is performed by the Institute for Protection and Nuclear Safety which is part of the CEA. The Report of the Safety Evaluation is then submitted to the Permanent Group, composed of experts and representatives of the services of the Ministry of Industry and Research, who are competent in the areas pertinent to nuclear reactor safety. (There are two other Permanent Groups competent in other nuclear areas.)

The comments of the Permanent Group along with those of other Ministries and local administrations and the results of a Public Inquiry are considered by an interministerial committee (Commission Interministérielle des Installations Nucléaires de Base) prior to issuance of a Draft Authorization Decree. Generally, the Public Inquiry procedure of the "Public Utility Status" review is used as the means of public participation.

It is notable that the Public Inquiry procedure is not an adverserial proceeding as with USNRC public hearings. Information presented in these procedures is viewed as being for the benefit of the government in its decision-making. The proceedings do not allow for cross-examination, discovery and either delay or appeal of governmental decisions.

A recent modification of past procedures requires a parallel review of non-radiological environmental impacts by the Ministry of Environment and the concurrence of this Ministry that a Construction Permit should be issued. To-date, this review has not resulted in a modification of the scope or form of the preliminary studies performed by E.D.F., and it is not viewed as imposing a significant departure from past practices.

After approval by the Health Ministry, the construction permit is issued by the Prime Minister after a report from the Minister of Industry and Research.

A safety review involving the Institute of Protection and Nuclear Safety and the Permanent Group is also performed at the end of construction when E.D.F. is required to submit a Provisional Safety Report, and before beginning of commercial operation when E.D.F. is required to submit a Final Safety Report (see Table 2.2).

Authorizations for the initial fuel loading and beginning of commercial operation are issued by the Service of Nuclear Safety.

The outline of the Safety Reports (Preliminary, Provisional and Final) is indicated in Table 2.5.

The Site Studies mentioned in Part I of the Table, as Described in (18), include:

1 - Description and History of the Site

2 - Meteorology

3 - Hydrology

4 - Geology and Seismology

5 - Radioecology

6 - Natural or Pre-existing Radioactivity at the Site.

* Description and History of the Site

This section is mainly descriptive and concerns

1 - a description of the site,

2 - the distribution of the population, in terms of demographic characteristics and the foreseeable evolution in magnitude and spatial distribution,

3 - uses of the land: agricultural, industrial and public, and

4 - the road network: access facilities, possible transportation hazards.

* Meteorology

This section involves:

1 - the description of regional meteorology,

2 - the description of local meteorology, and

3 - the studies of diffusion and transport of gaseous effluents.

An appropriate model describing the transport of gaseous effluents is proposed. Eventually, tracer studies are proposed to provide more accurate knowledge of the different paths of effluents (influence of topography and of special atmospheric conditions).

* Hydrology

The objective is to achieve evaluation of liquid effluent transport during normal operation and in the event of an accident.

The possible transport paths in different bodies of water (surface or underground) must be investigated, and if necessary, descriptive models taking into account velocity, channeling by underground impervious layers, and radioactive ion exchange in soils must be proposed.

* Geology and Seismology

This section involves:

1 - a description of regional geology,

2 - a detailed study of the stratigraphy and tectonics of the site with special investigation of accidents and faults, and

3 - local and regional seismic history.

Care is taken to complete and specify available historical seismic data by an experimental study aimed at better knowledge of epicentral spots and seismic response of the surrounding soil layers.

Such an investigation should attempt to propose a model of seismic data to be taken into account in the design of the plant. The elements would be frequency spectrum, amplication by soil layers and estimated magnitudes of sources.

* Ecology

This section must deal with the transfer of radioactive contaminants through biological media (flora and fauna)

in order to evaluate the impacts on natural and human species of radioactive releases. In particular, critically important pathways must be investigated. The possible effect of thermal release to water or air on natural biota must also be addressed.

* Natural or Pre-existing Radioactivity at the Site

This section involves a detailed description of the influence of the main radioactive sources that exist at the site before operation of the nuclear plant. Natural radioactivity levels (cosmic exposure, telluric activity, waters and biota activity) and other radioactive sources, such as fallout and impacts of other nuclear installations in the vicinity, are investigated.

The objective is to provide sufficient information to prescribe design and operating measures that will avoid detrimental or unacceptable consequences in normal as well as accidental situations.

2.5 Conclusions

In the review in the previous sections, some characteristics of the French siting process and licensing procedures that are of significant importance for a comparison with corresponding U.S. practices have been illuminated. These points show a close cooperation between French licensing authorities and E.D.F. to achieve the development of a nuclear program at a national level.

Moreover, it can be seen that the debate over particular sites takes place in the early stages of the power plant

planning process, so that a decision regarding the overall need for the project is taken before major investments are committed for the plant construction. In particular, the public participation is first informally involved at the Preliminary and Draft Studies stages, and then officially required during the "Public Utility Status" review - simultaneously with the construction permit review. And there is no additional direct involvement of the public in the following stages of the licensing process which might induce fundamental changes in the decisions of the licensing authorities.

An important difference from the United States practice in the way in which these reviews are conducted is that they rely much more on the judgement of the E.D.F. staff regarding what matters merit significant attention, and the manner in which they are addressed. French practice lacks the hierarchy of congressional legislation, federal regulations, NRC Regulatory Guides, etc. which are used in the United States to specify the desired format, content, and judgemental criteria for safety and environmental analyses. Thus, the French system ends up being much less rigid and legalistic, but also much more reliant on the integrity and good judgement of the individuals involved than the American system.

Table 2.1. LIST OF FRENCH NUCLEAR POWER PLANTS[2]

Plant Name	Capacity (Net MWe)	Type	Date of Commercial Operation
Marcoule G2	40	GCR	4/59
Marcoule G3	40	GCR	5/60
Chinon 2	210	GCR	2/65
Chinon 3	400	GCR	8/67
Monts d'Arrée	70	GCHWR	7/67
Saint-Laurent-des-Eaux 1	460	GCR	3/69
Saint-Laurent-des-Eaux 2	515	GCR	8/71
Bugey 1	540	GCR	4/72
Phénix	233	LMFBR	12/73
1970 PROGRAM (8,000 MW PWR)			
Fessenheim 1	890	PWR	3/77
Fessenheim 2	890	PWR	6/77*
Bugey 2	925	PWR	7/77*
Bugey 3	925	PWR	10/77*
Bugey 4	925	PWR	6/78*
Bugey 5	925	PWR	12/78*
1974 PROGRAM (14,800 MW PWR)			
Tricastin 1	925	PWR	3/79*
Gravelines B1	925	PWR	5/79*
Dampierre 1	925	PWR	8/79*
Tricastin 2	925	PWR	9/79*
Gravelines B2	925	PWR	11/79*

*Estimate as of December 1976

Table 2.1. (Continued)

Plant Name	Capacity (Net MWe)	Type	Date of Commercial Operation
Dampierre 2	925	PWR	2/80*
Tricastin 3	925	PWR	4/80*
Gravelines B3	925	PWR	6/80*
Dampierre 3	925	PWR	8/80*
Tricastin 4	925	PWR	10/80*
St. Laurent B1	925	PWR	11/80*
Le Blayais 1	925	PWR	3/81*
Gravelines B4	925	PWR	2/81*
Dampierre 4	925	PWR	4/81*
St. Laurent B2	925	PWR	6/81*
Le Blayais 2	925	PWR	10/81*
1976 PROGRAM (19,650 MW PWR)			
Chinon 1	925	PWR	81*
Site 2 Unit 1	925	PWR	82*
Site 3 Unit 1	925(option)	PWR	82*
Chinon 2	925	PWR	82*
Site 4 Unit 1	925(option)	PWR	82*
Site 2 Unit 2	925	PWR	83*
Site 3 Unit 2	925(option)	PWR	83*
Site 4 Unit 2	925(option)	PWR	83*
Site 5 Unit 1	925(option)	PWR	83*
Site 5 Unit 2	925(option)	PWR	84*

*Estimate as of December 1976

Table 2.1. (Continued)

Plant Name	Capacity (Net MWe)	Type	Date of Commercial Operation
Paluel 1	1300	PWR	82*
Flamanville 1	1300	PWR	83*
Paluel 2	1300	PWR	83*
Flamanville 2	1300	PWR	84*
Site 3 Unit 1	1300(option)	PWR	84*
Site 4 Unit 1	1300(option)	PWR	84*
Site 3 Unit 2	1300(option)	PWR	84*
Site 4 Unit 2	1300(option)	PWR	85*

*Estimate as of December 1976

TABLE 2.2 French Siting Process and Licensing Procedures

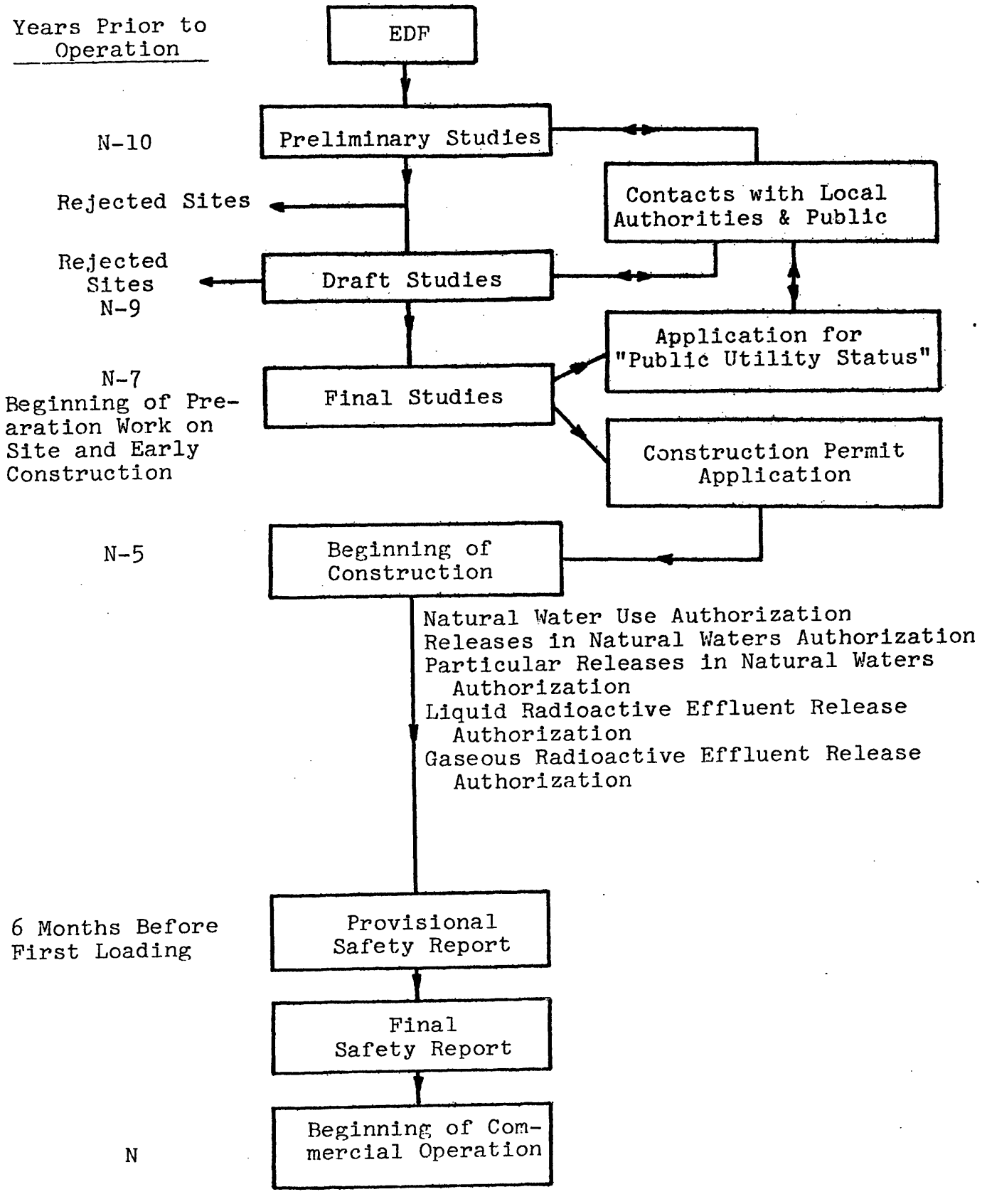


TABLE 2.3 Topics in Preliminary Site Survey Studies

- General nationwide studies
- Literature and in-situ survey of potential sites
- Cooling capabilities
- Geology
- Accessibility
- Socio-economic environment

Table 2.4

Detailed Subjects of Draft Site Selection Studies

Detailed analysis of the characteristics of the site

- Hydrology or study of local currents for coastal sites
- Geology
- Meteorology
- Socio-economic conditions

Environmental studies

- Temperature increase of cooling waters
- Impacts of chemical releases
- Radio-ecological studies
- Study of indigenous ecosystem
- Noise studies
- Aesthetic studies

Safety related studies

Risks associated with possible natural and manmade hazards to the plant:

- Natural phenomena (seismic activity, floods, etc.)
- Human activities (proximity of roads, airlines, industrial activities, etc.)

Possible reactor accident consequences (exposure of affected populations)

Draft design of the plant

- Siting of the buildings and transmission lines
- Aesthetic studies
- Possible alternatives
- Evaluation of the cost of the project

Socio-economic impact during construction and operating period

TABLE 2.5[15]

Plan of the Safety Reports

Part I: Introduction and Generalities

* Introduction
* Site
* General characteristics - Main technical options
* General safety principles
* Summary of the safety analysis: radiological impacts of accidents
* Storage, control and release of radioactive effluents and waste
* Organization of the construction and operating stages
  - Protection of workers
* Education and training of personnel

Appendices:

- Table of site and plant characteristics
- General drawings
- Site-related tables and drawings

Part II: Power Plant Equipment and Operation

* Generalities
* Civil engineering
* Nuclear Steam Supply System and related safety equipment
  - Fuel
  - Core-primary coolant loop
  - Fuel handling
  - Related safety equipment
* Containment building and related safety equipment
* Nuclear auxiliaries
* Secondary coolant loop
* General quxiliaries
* Electric equipment

(continued)

TABLE 2.5 (Continued)

* Control systems
* Reactor physics
* Operation

Appendices: Responses to questions of the licensing authorities

Part III: Safety Analysis

* Quality of the construction
  - General construction specifications
  - Quality control
* Tests of the safety concepts used for the design
* Detailed Safety Analysis (prevention - control - action means)
  - Core
  - Primary circuit
  - Primary confinement
  - Containment building
  - Handling
  - Safety of secondary circuits
  - Safety of auxiliaries
* Classes of accidents - accidental releases
* Radiation exposure protection
  - Organization of personnel protection
  - Control of releases and effluents
* Test results

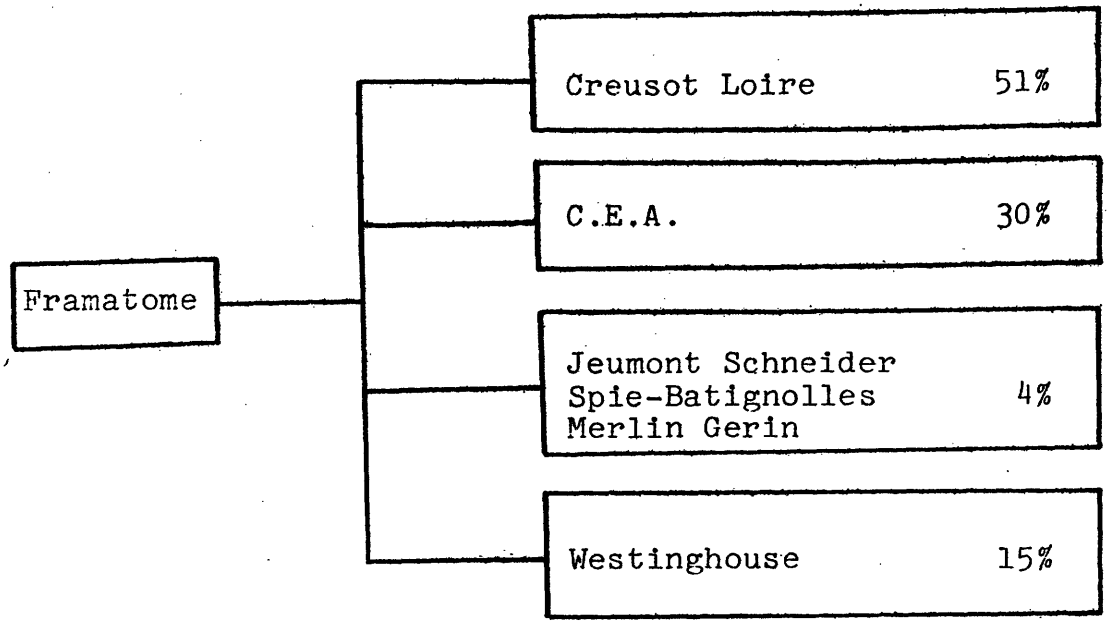


FIG. 2.1 Current Ownership of Framatome[3]

FIG. 2.2 "Public Utility Status" Licensing Procedure[14] from application to decision to proceed with the "Public Enquiry" stage.

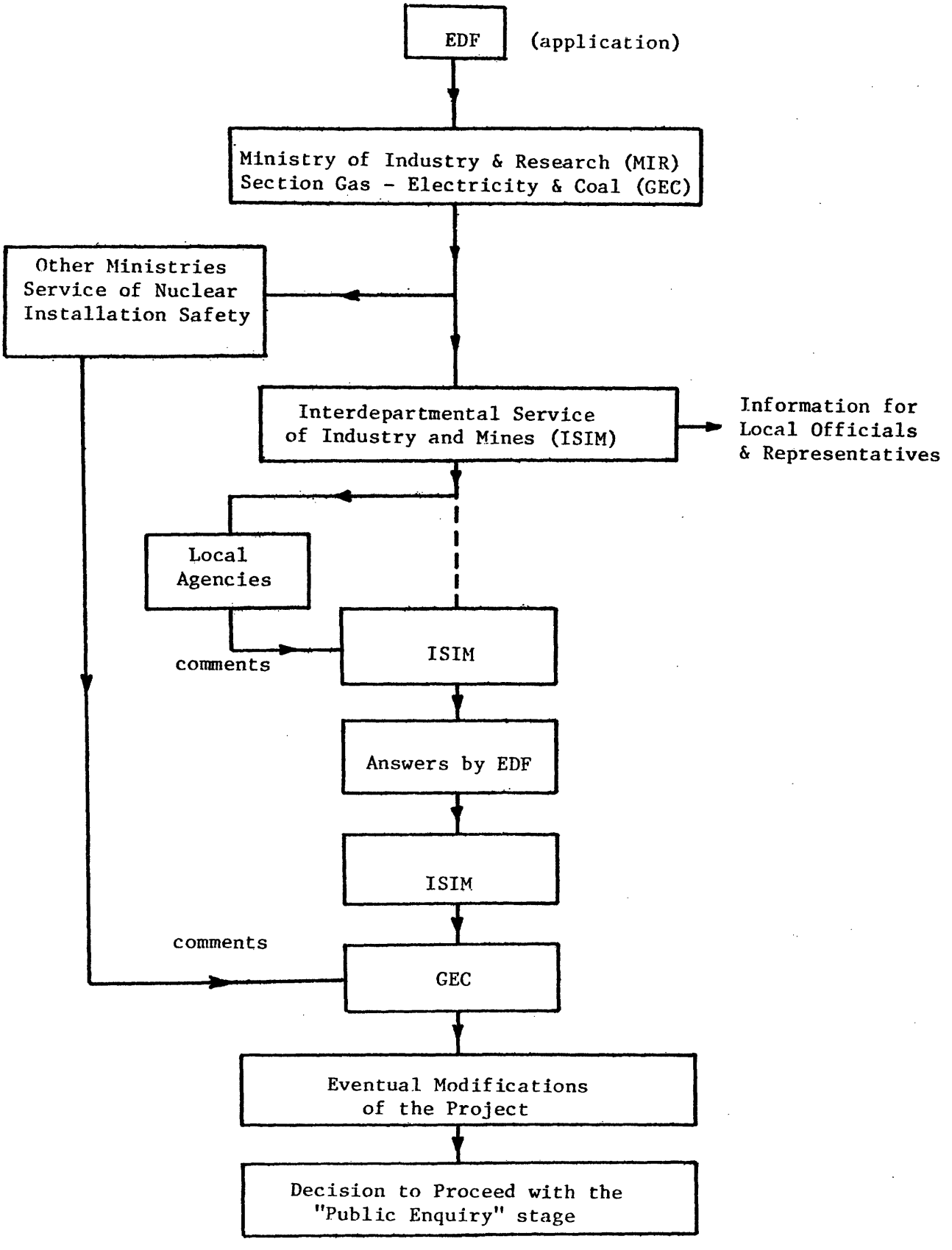


FIG. 2.3 "Public Utility Status" Procedure[14] from decision to proceed with the "Public "Enquiry" stage to issuance.

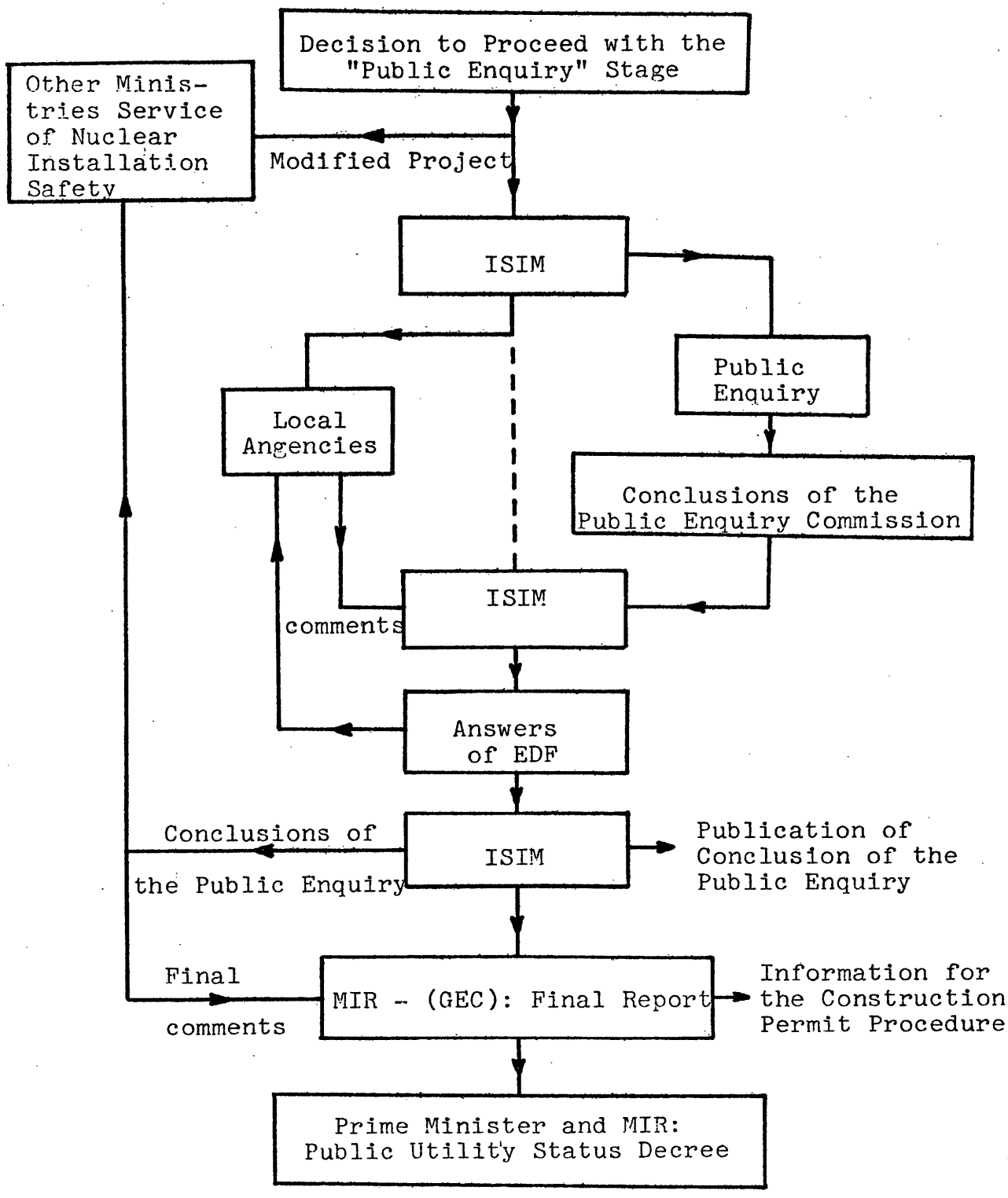
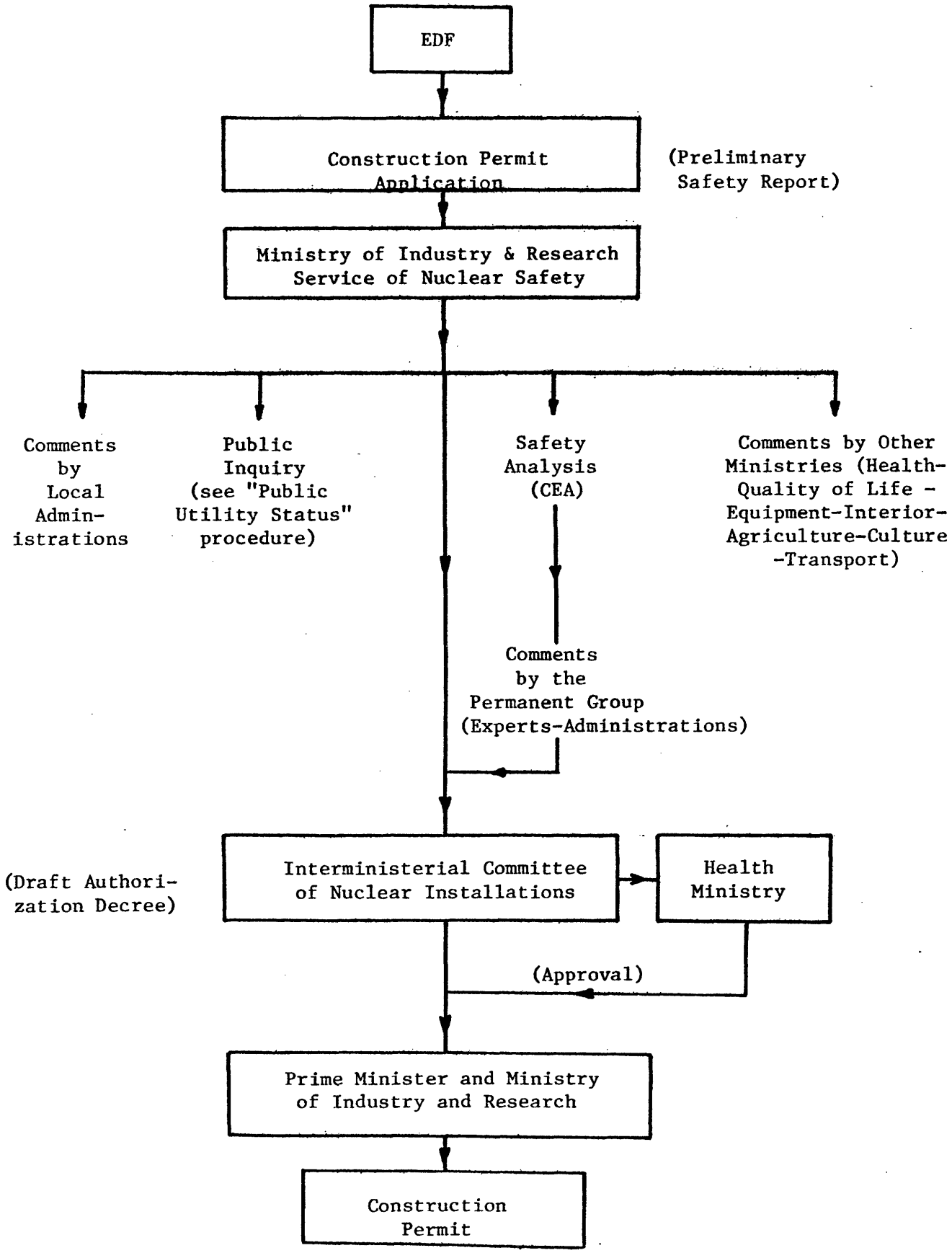


FIG. 2.4 Construction permit procedure in the French[14] nuclear licensing process



3. U.S. LICENSING PROCEDURES

The rules and standards governing the nuclear power plant licensing process in the U.S. are contained in Title 10 of the Code of Federal Regulations (CFR) (19). The licensing process consists of two distinct stages: first, application for and issuance of a power plant Construction Permit; and, simultaneously with the last stages of plant construction, application for and issuance of an Operating License.

An average time of some 12 years is currently required from the date that a utility makes a decision to build a nuclear power plant until the completed facility is ready to operate under a Nuclear Regulatory Commission (NRC) license (20). Figure 3.1 outlines the U.S. nuclear power plant licensing and construction process, from final selection of a site to beginning of commercial operation. Section 4 provides historical information regarding the delays occurring in the U.S. licensing process.

3.1 Construction Permit Stage

Obtaining a Construction Permit for a nuclear power reactor involves:

- First, the filing and acceptance of an application consisting of a Preliminary Safety Analysis Report (PSAR) containing the proposed design of the plant, an Environmental Report (ER) documenting the environmental impacts of the site preparation activities and of the construction and operation of the power plant and its auxiliary equipment, and affidavits

confirming the compliance of the utility with all Federal antitrust legislation;

- Second, antitrust, environmental and safety review by the NRC staff;
- Third, a safety review by the independent Advisory Committee on Reactor Safeguards (ACRS); and
- Fourth, a mandatory public hearing by a three-man Atomic Safety and Licensing Board (ASLB). Following the hearing, the ASLB makes an initial decision as to whether the permit should be granted.

The NRC's staff antitrust, safety and environmental reviews proceed in parallel as shown in Figure 3.2.

Additional federal reviews are conducted by the Environmental Protection Agency (primarily concerned with the adequacy of the waste heat disposal system), and the Army Corps of Engineers (regarding the acceptability of water withdrawal and discharge structures in navigable waterways), as well as other agencies. However, these are not usually the reviews which have the primary impact upon plant schedule and costs (notwithstanding notable exceptions, of which the Seabrook case is probably the most prominent example).

3.1.1 Antitrust Review.

As shown in Figure 3.1, the antitrust review begins long before the safety and environmental analyses. Regulations require applicants to submit to the NRC the antitrust information at least nine months and as early as 36 months before other parts of the

Construction Permit application are filed for acceptance review (20).

The NRC holds a hearing when recommended by the Attorney General or by private intervenors. An Atomic Safety and Licensing Board (ASLB) is appointed by NRC, as in all hearings, and decides upon the acceptability of the antitrust evidence presented.

Although the antitrust review seldom leads to significant licensing delays or public information (19), these aspects are recognized as having potential for causing significant delays in new plants (21). But they relate to factors which are usually outside the regulatory process and therefore will not be addressed further.

3.1.2 Environmental and Safety Reviews.

Following a preliminary review with the applicant to assure that all information submitted is in order, the NRC accepts the application and it is recorded as accepted or docketed.

Various segments of the PSAR and the ER are then reviewed by the NRC staff, according to the detailed sequence shown in Figure 3.3 (21). Main branches of Figure 3.3 are shown in individual paths in Figure 3.4. In actual practice, all paths are pursued concurrently with contacts between parallel paths being made at appropriate levels.

A notice of receipt of application is published in the Federal Register, and copies of the application are furnished to appropriate state and local authorities and to a public document room established in the vicinity of the proposed site. At the

same time, a notice of public hearing is published in the Federal Register and local newspapers which provides 30 days for members of the public to petition to intervene in the proceeding. These petitions are considered by the ASLB appointed to the case (20).

* Environmental Review

The Environmental Report (ER) submitted by the applicant must discuss:

- The site and reactor characteristics;
- Power needs in the area;
- The environmental effects of site preparation, and plant and transmission facilities construction;
- The environmental effects of plant operation;
- Effluent and environmental measurements and monitoring;
- The environmental effects of accidents;
- The economic and social effects of plant construction and operation;
- Alternative energy sources and sites; and
- Plant design alternatives.

Moreover, a demonstration must be made, through a cost-benefit analysis, that the aggregate benefits of the project outweigh the aggregate costs before a positive licensing decision can be issued.

The NRC has published Regulatory Guides which describe its attitude towards safety and environmental criteria and provide

information about the necessary data expected to be found in the PSAR's and ER's. For example, Regulatory Guide 4.7 (General Site Suitability Criteria for Nuclear Power Stations) describes the environmental regulation concerning the general site suitability of Nuclear Power Stations. As indicated in Figure 3.4, a utility can request an accelerated environmental review of the site preparation and plant construction processes for the purpose of obtaining a Limited Work Authorization (LWA). Application for the LWA requires that the utility's ER be submitted up to six months prior to its PSAR. Under the LWA, the utility may begin, at its own risk, preliminary site preparation work such as clearing of the land, excavation and construction of non-nuclear facilities. Construction of nuclear facility foundations can be undertaken under supplemental LWA's, subject to NRC approval of the foundation design (19). The LWA allows beginning of construction about 8-14 months prior to issuance of a Construction Permit.

After review of the ER, the NRC staff issues a Draft Environmental Statement (DES). The content of the DES is determined by the National Environmental Police Act (NEPA) of 1969 as implemented by the NRC, following the (1971) U.S. Court of Appeals decision related to the Calvert Cliffs Nuclear Power Plant.

The DES is reviewed by Federal, State and local agencies and other interested persons (20); their comments are taken into account in the preparation of a Final Environmental Statement

(FES). Both documents are made available to the public.

The FES is then considered at the public hearing by the Atomic Safety and Licensing Board (ASLB).

* Safety Review

As indicated in Figure 3.4, the review of the PSAR, simultaneously by the NRC staff and the Advisory Committee on Reactor Safeguards (ACRS), begins almost immediately with the docketing of the application. The results of the staff's safety review are embodied in a Safety Evaluation Report (SER).

After completion of the safety review by the ACRS, the NRC staff issues a supplement to the Safety Evaluation Report which discusses any action taken as a result of ACRS recommendations. A public hearing regarding safety issues is then held. Environmental and safety hearings follow similar procedural steps before the ASLB, but the environmental hearings are usually completed about eight months sooner (21), as indicated in Figure 3.4. This implies that separate hearings regarding safety and environmental matters must be held, although a single hearing may legally cover both safety and environmental factors.

Regulatory Guide 4.7 describes the regulation on safety issues concerning the general site suitability of Nuclear Power stations. The safety portion of the application is organized in accordance with the NRC guide "Standard Format and Content of Safety Analysis Reports" which describes the information needs of the NRC for review. These include analyses of such engineered

safety features as the reactor containment vessel, earthquake protection systems and the reactor's Emergency Core Cooling System (ECCS).

3.2 Operating License Stage

When the plant is nearing completion, the applicant must go through similar safety and environmental reviews for the Operating License, as indicated in Figure 3.1. The utility must submit to the NRC a Final Safety Analysis Report (FSAR) describing any changes made during construction which affect the safety of the plant's operation or emergency shutdown procedures, programs for preoperational testing and subsequent monitoring of the reactor operation, and an Environmental Report (ER) containing the projected environmental impacts of continuous plant operation and any other environmental information not supplied at the time of the Construction Permit review (19).

The Operating License stage does not include any Antitrust Review, all these matters having been definitely decided prior to issuance of the Construction Permit.

A public hearing is not mandatory at the operating license stage, but one may be held at the initiative of the NRC or if requested by intervenors (as is being done with increasing frequency).

3.3 Federal, State and Local Regulations

A number of federal, state and local agencies have some responsibility in the establishment and enforcement of regulations affecting the licensing of nuclear power plants.

Local governments exert control over zoning, while states manage their regulations through various means, including Public Utility Commissions, power plant siting and land-use control legislation, air/water pollution control, dredge and fill regulations and Coastal Zone Management regulations among others (21).

At the state level, an increasing awareness of environmental problems is developing which has led to the creation of siting laws in various states. These laws are aimed at giving the states more responsibility in the choice of sites for nuclear power plants, and often they require the utility companies to submit to the states applications for a preferred site and two or three alternative sites. These procedures can involve additional hearings regarding environmental or safety matters. For example, Washington State in 1973 established a Thermal Power Plant Site Evaluation Council. The Council is charged with making all regulatory reviews prior to granting an approval to a siting application. The Council conducts hearings and submits a recommendation to the Governor concerning the site application. The Governor is then the final authority for the state to approve or reject the site application (22). Similarly, an Ohio law created in 1972 a Power Siting Commission to control the location of major utility facilities. In order to obtain a certificate of environmental compatibility and public need, the proposed facility must meet all air pollution, water pollution and solid waste disposal laws, regulations and standards, in addition to other siting criteria prescribed by the power siting law itself. Application for certification must be filed two to five years in advance of construction (22).

At the Federal level, utilities also have to apply to the Environmental Protection Agency (EPA) for a National Pollution Discharge Elimination System Permit (NPDES Permit). Consequently federal legislation, such as the Federal Water Pollution Control Act Amendments of 1972, is being enforced concurrently by the NRC and the EPA. Overlapping jurisdiction between these two federal agencies has been recently recognized and an attempt to improve the situation has been made through the December 1975 Second Memorandum of Understanding between these agencies.

In summary, the licensing of a nuclear power plant on a particular site involves application to approximately 17 federal, state and local agencies for 46 permits or approvals, with these values varying slightly according to state and local conditions. This implies duplication of the numerous issues documented, and is a source of conflicting decisions and delays.

3.4 Conclusions

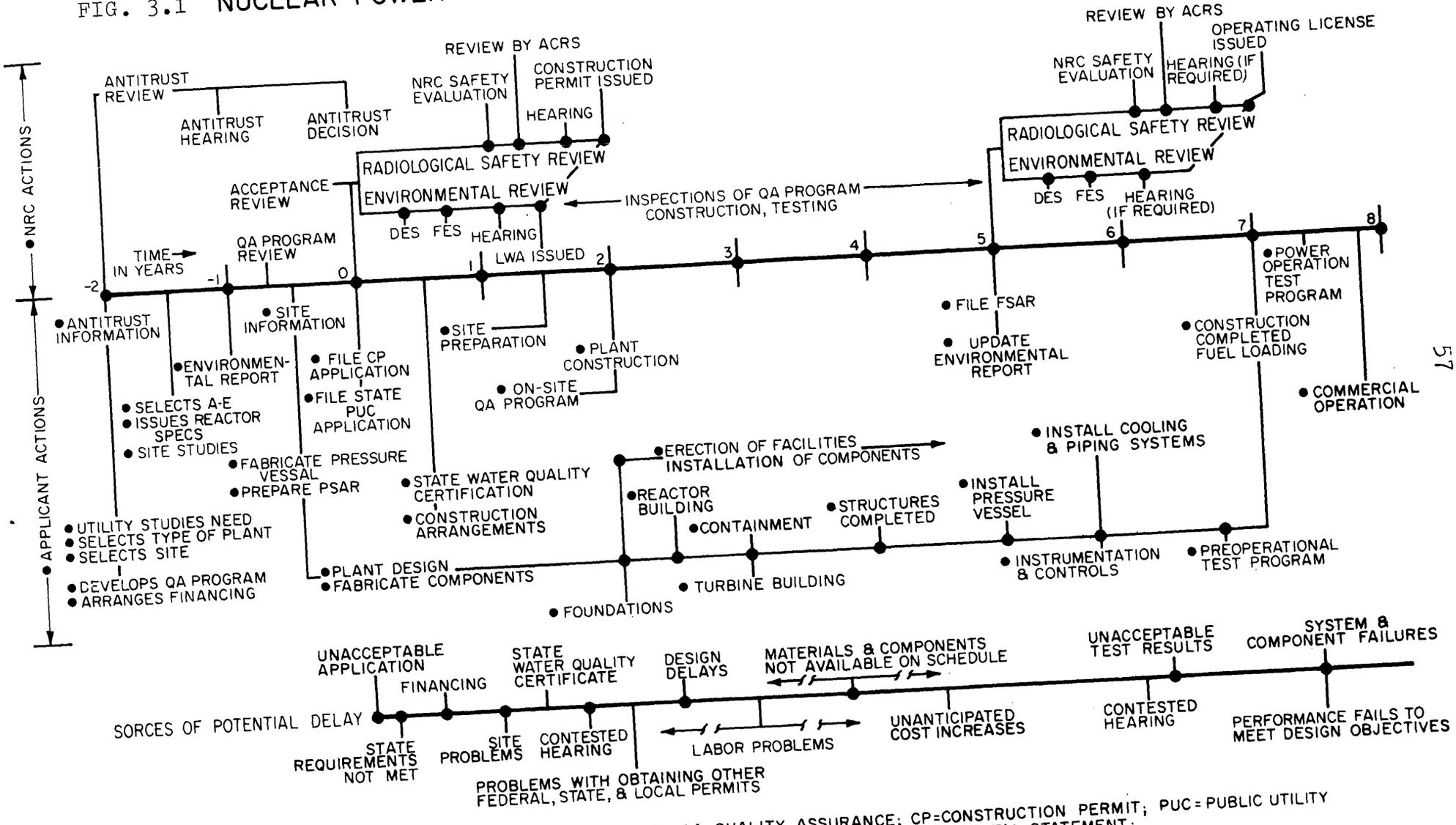
The U.S. licensing process for nuclear power reactors reviews antitrust, safety and environmental matters by involving public officers, experts and the general public.

The review takes place at the federal, state and local levels. Very detailed legislation has been and is being designed at these three levels; in particular, environmental legislation, although currently enforced by two federal agencies, is also developing at the state and local levels.

Public participation is involved through public hearings; these are mandatory at the Construction Permit stage and

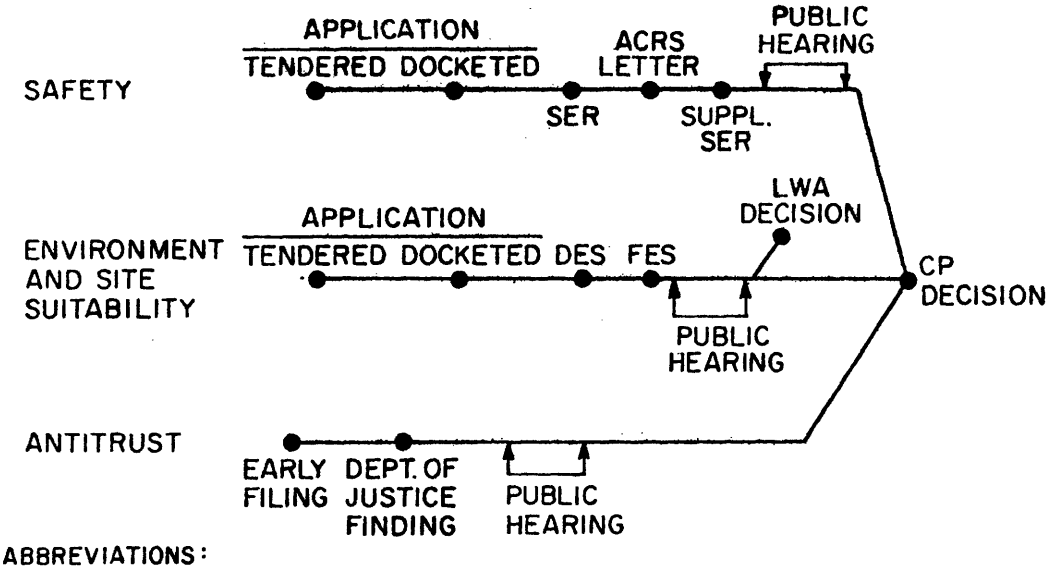
their practice is now becoming general at the Operating License stage, in the last stages of plant construction, upon the request of intervenors.

FIG. 3.1 NUCLEAR POWER PLANT LICENSING AND CONSTRUCTION PROCESS



ABBREVIATIONS: AE=ARCHITECT ENGINEER; QA=QUALITY ASSURANCE; CP=CONSTRUCTION PERMIT; PUC=PUBLIC UTILITY COMMISSION; DES=DRAFT ENVIRONMENTAL STATEMENT; FES=FINAL ENVIRONMENTAL STATEMENT; LWA=LIMITED WORK AUTHORIZATION

FIG. 3.2 PARALLEL TRACKS IN CONSTRUCTION PERMIT REVIEW PROCESS



ABBREVIATIONS:

SER-SAFETY EVALUATION REPORT

FES-FINAL ENVIRONMENTAL STATEMENT

ACRS-ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

DES-DRAFT ENVIRONMENTAL STATEMENT

LWA-LIMITED WORK AUTHORIZATION

FIG. 3.3 Schematic diagram of NRC licensing process to Construction Permit stage

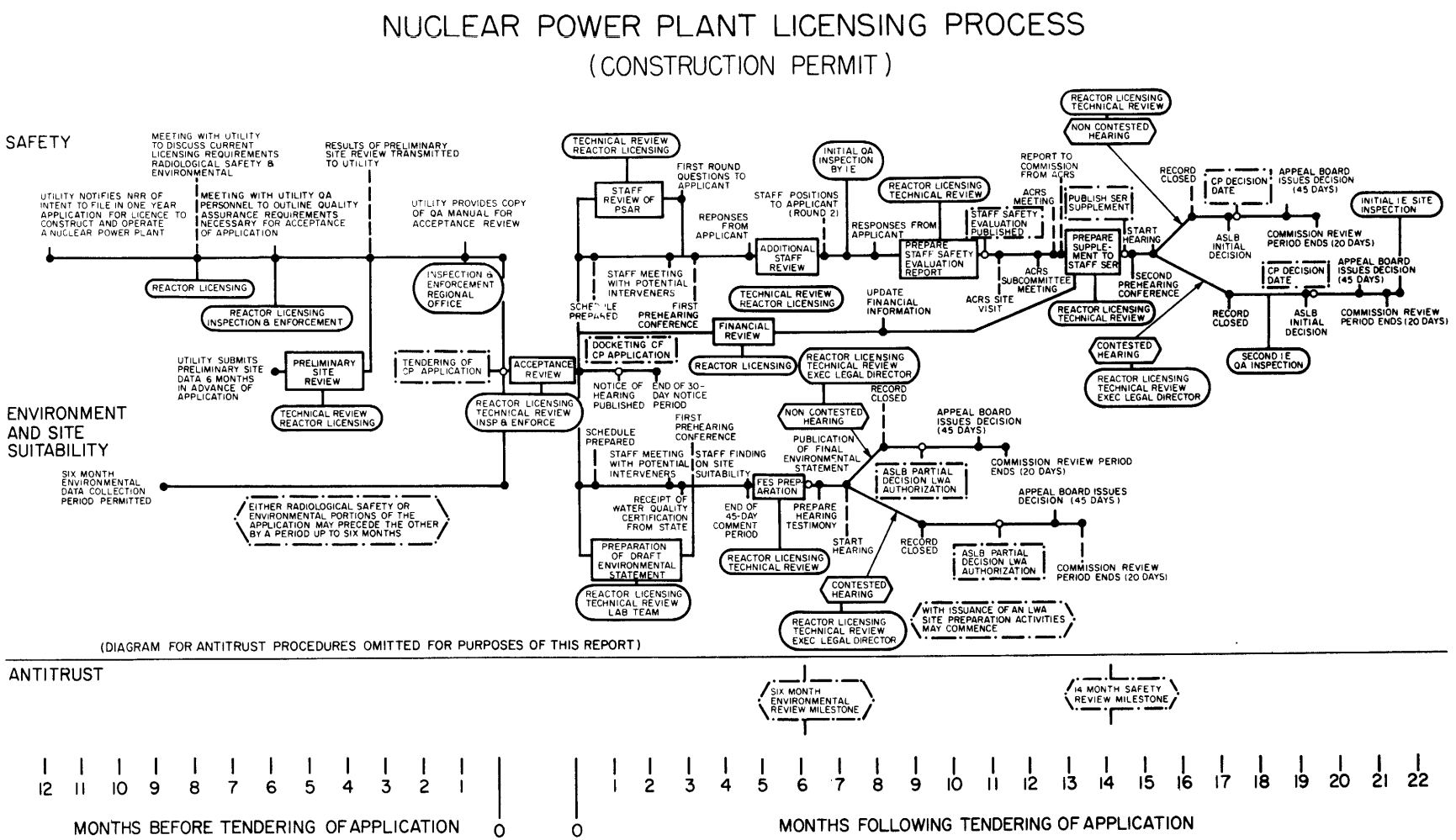
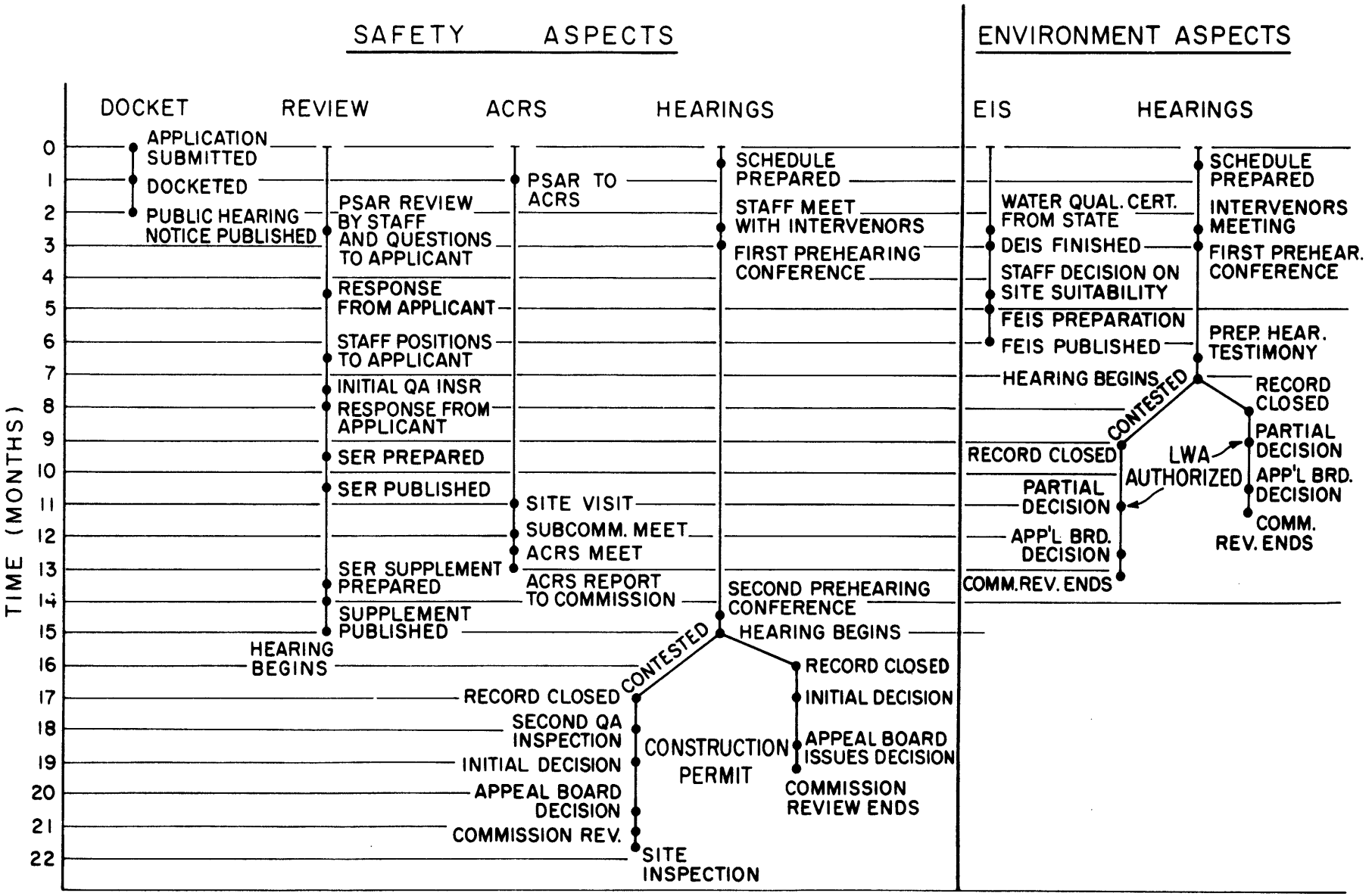


FIG. 3.4 CONSTRUCTION PERMIT



4. HISTORICAL ANALYSIS OF DELAYS IN THE LICENSING PROCESS FOR POWER REACTORS IN THE UNITED STATES

In order to examine the historical development of power plant construction and operational schedule disruptions a survey of the experience of the United States nuclear utilities and of the available literature was conducted. Each of the U.S. nuclear electric utility companies was polled by a questionnaire, and later in telephone conversations, regarding the licensing, plant construction, financial, and operational history of each of its nuclear power plants.

4.1 Structure of the Sample Considered in the Study

Using available information in the literature, a sample of 183 commercial nuclear power plants has been established. Of these, 46 are reactors which have been docketed from 1965 to 1976 and are being operated, 133 have been docketed during the same period and are still in the licensing process, and four correspond to applications submitted to NRC in 1976 which are not yet docketed.

The distribution of the reactors of the sample in the various stages of the licensing process is shown in Figure 4.1 as a function of Docket Date. It can be seen that the youngest reactors in operation today have been docketed in 1969 but two reactors docketed in 1966 are still in the Operating License stage of the process. Another striking characteristic is the dramatic decrease of the number of applications submitted per year after 1974. This number falls from 43 in 1974 to four in 1976. Among other reasons, this can be attributed to permanent

changes in the regulatory process and criteria and to other uncertainties that are affecting the nuclear industry. It must be noted that some of these factors are not specifically related to nuclear problems and apply to the electrical industry in general. These uncertainties are well illustrated by the poor performance of the utilities in projecting the duration of the nuclear plant licensing and construction periods.

4.2 Overall Length of Licensing and Construction Periods: Projected and Actual Values

The duration of the licensing and construction period can be represented by the time between the Docket Date and the Operating License issuance, which corresponds approximately to the duration from the official beginning of actual evaluation of a construction permit application starting at the Docket Date to the commercial operation a very short time after receipt of the operating license.

Figure 4.2 shows the actual and the projected length of the licensing and construction period as a function of the Docket Date (year of application). The data of the figure represent average durations for the plants having submitted applications in a particular year. The "actual" points are averages over total lengths of the processes for plants which are now in operation and the most recent estimates of that period, for plants which submitted applications in the same year but which are not yet in operation.

The ratios between brackets are the ratios of the numbers of plants in operation to the total number of plants having been docketed in the same year. With the exception of a few plants for which projected values were not available, these numbers represent all the applications submitted from 1965 to 1976.

The results are similar to those obtained in 1974 with a smaller sample by Irvin C. Bupp in his study of LWR capital costs (23).

Clearly the average period from application to operating license has been increasing roughly linearly from 63 months to 126 months for plants that have been docketed between 1965 and 1971.

Simultaneously, the delay between expected and actual beginning of operation has increased from 23 to 45 months.

For the plants docketed after 1971, no information is yet available concerning actual total licensing durations.

Nevertheless, assuming that actual and projected curves have the same shape, we may expect from the shape of the projected curve that the tendencies toward longer licensing durations will have remained valid until the docket date of 1974, with some leveling-off occurring for plants docketed later.

The result is confirmed by the more detailed analysis performed in the following sections.

4.3 Construction Permit Procedure

Figure 4.3 shows the distribution of the lengths of the period from application to construction permit issuance for almost all the plants of the sample between 1965 and 1974. The curves represent the upper and lower mid-mean values and the yearly averages.

As can be seen in Figure 4.1, all plants docketed prior to 1971 have received construction permits, but since 1971 a fraction of the plants docketed each year have not yet received construction permits (33%, 0%, 43%, and 91%, respectively for the years 1971, 72, 73 and 74, and 100% for the subsequent years). Therefore, the averages calculated for the years 1971 through 1974 represent minimal values that will be increased when every plant in the yearly samples has received its construction permit (except for the year 1972).

It can be seen that the average period necessary to obtain a construction permit varies from 10 months for plants docketed in 1965, to 22 months for plants docketed in 1972 and reaches a maximum of 38 months for the plants docketed in 1971.

In Figure 4.4 revised data regarding the duration from docketing to Construction Permit issuance are shown. These data differ from those of the previous figure in that the effects of utility-mandated plant deferrals from the originally scheduled construction date have been subtracted. This primarily reflects the effects of the large number of deferrals which have occurred since the 1973-74 Arab oil embargo, and the ensuing fluctuations in energy demand. These deferrals are departures from the

routine scheme of plant licensing and have the effect of obscuring the significance of the data. It is seen that the Construction Permit licensing duration is anticipated to be slightly lower than that for plants docketed near the time when NEPA-Calvert Cliffs decision modification to the licensing process occurred. Whether this will actually occur is doubtful since the actual licensing time consistently tends to be longer than estimated, and the data sample for the docketing years 1971-74 includes plants which are still in licensing. Comparison of Figures 4.3 and 4.4 shows that the licensing time-peaks in Figure 4.3 are largely eliminated when utility deferral delays are taken into account.

Generally, all the plants have followed the same tendencies and the differences between mean duration values and individual plant duration values have been of the order of plus or minus two or four months, except for the years 1969, 1970 and 1971, for which the differences have been of the order of plus or minus 15 months. The construction permit procedure can be divided into two stages, first the review by the NRC staff concluded by the decision of the Advisory Committee or Reactor Safeguards (ACRS) and then the public hearings concluded by the Hearing Board decision. The contributions of each of these two steps to the duration of the period between application and construction permit issuance have been investigated.

The same type of results as those shown in Figure 4.3 are shown for each of these stages in Figures 4.5 through 4.7.

4.4 Operating License Procedure

For all the plants of the sample which have received construction permits, the same type of results as those given in Figures 4.3 to 4.7 are given in Figure 4.8 for the length of the period between construction permit and operating license. For the operating license issuance date, actual values and most recent estimates have been used.

Because of the increasing number of estimates for the dates of operating license issuance and the higher fractions of plants which have not yet received a construction permit in the data, the average values displayed corresponding to the years 1971 to 1974 must be considered as the lower limits of the licensing duration rather than as being representative of the ultimate mean values.

From Figure 4.1 we see that the most recent estimates of the total durations for the year 1972, 1973 and 1974 seem unrealistically low because they are so much smaller than the values for the preceeding years. Therefore, we may expect the ultimate average values of the data of Figure 4.8 for these years to be significantly greater than the values shown, as plants currently going through licensing finish that process at later dates.

The licensing duration from CP issuance to Operating License (OL) issuance is used for construction of the power station, and it is seen that it is much longer than the CP licensing phase, with a typical current value of 80 months.

The impacts of the Calvert Cliffs decision and of the AEC hearings regarding the adequacy of the Emergency Core Cooling System (ECCS) at approximately the same time in affecting the durations of the NRC review is clearly visible in Figure 4.5. It is seen that a peak is reached in the duration from docketing until ACRS action for those plants docketed in the 1969-1971 interval. After the "transient" caused by the sudden introduction of a greatly increased scope of regulatory review died away the more stable duration of an average of 15 months (for the plants docketed after 1971) is observed. The period from docketing to ACRS action is used mainly for the reviews and subsequent questions by the NRC staff of the Environmental Report and Preliminary Safety Analysis Report submitted by the applicant. The approximate doubling of the average duration for this review between the docketing years of 1966 and 1973 is caused principally by greatly increased scope in the safety and environmental reviews, and by the requirement that correspondingly more complex and costly power plants be designed. It is notable that the spread in the data (indicated by the upper- and lower-mid mean licensing duration curves) is typically of the order of 20% of the mean value.

The licensing duration from ACRS action until CP issuance is shown in Figure 4.6. It is seen that the mean licensing duration has grown by a factor of approximately four during the past decade, and that the relative spread of the data is much greater than in the previous figure, with a typical

deviation of the upper or lower mid-mean being of the order of 50% of the mean licensing duration value. This indicates in the past-ACRS phase of licensing that much greater uncertainty is associated with being able to proceed on-schedule than in the pre-ACRS phase. Most of this phase in the NRC reviews is concerned with public hearings prior to an ASLB decision on the CP. It should be noted that while this discussion has focussed on NRC actions, simultaneously other federal and state agencies are conducting their own reviews of the power station proposal, and the delays caused by these reviews are also imbedded in these data. Thus, as is shown in Figure 4.7, the licensing duration prior to ACRS action is typically longer than the duration from ACRS action to CP issuance. However, it is important to note four points:

1. In earlier years (docket years 1966-1968) the post-ACRS interval was very short, indicating relatively little public interest in reactor licensing; and in later years (after 1969) the post-ACRS duration has grown to values only slightly smaller than those of the pre-ACRS duration, reflecting the emergency of the nuclear power controversy as a significant social issue,
2. The relative uncertainty associated with being able to maintain a particular licensing schedule is much greater in the post-ACRS phase than in the pre-ACRS phase.

3. The durations of both licensing phases have grown significantly during the past decade, and
4. During both licensing intervals the upper-mid-mean deviations from the mean licensing duration values are typically greater than similar deviations between the lower mid-mean and mean values - indicating that a small portion of the power plants experienced much longer licensing durations than the typical plant, and that a significant portion of the plants experienced licensing durations shorter than the mean duration.

One can see in Figure 4.7 that the two average curves have the same shapes and reach a maximum for the year 1970. The fourteen month additional delay shown in Figure 4.1 from 1965 to 1972 consists of additional delays of 7 months for the ACRS action of 7 months for the Hearing Board approval.

All plants have been affected the same way by additional delays to ACRS action, but they show very different performances with respect to the duration of the hearing period. Regardless of the variations of the mean duration curve, every year until 1974 some plants have been able to go through the hearing period with a duration of the same length as the prevailing values during 1956-1966 (approximately three months).

Some values of the data of Figures 4.5 through 4.7 do not add exactly to the corresponding value shown in Figure 4.3 because of some short lead times (1 to 3 months) between Hearing Board approval and effective construction permit issuance.

It is seen that the mean value of this licensing duration has increased by approximately 40% during the past decase - as power plants have become larger and more complex. However, the scatter of the data is relatively smaller than is seen in the data for the CP licensing intervals. Economically, this is still most important since the great fraction of power station costs are incurred in the post-CP phase of power plant licensing. Once the plant is built even small delays can be expensive, with current idle plant charges being of the order of $250,000 per day. The bias towards a portion of the plants having shorter licensing durations that the mean observed previously is also seen in these data.

Finally, one sees that the licensing performances of individual plants vary widely from the average, this characteristic being true for all years from 1966 to 1974. For example, the data for docket year 1968 show an approximate factor of two between the maximum and minimum post-CP licensing duration and deviations of approximately 17% (one year) and 21%, respectively of the lower- and upper mid-mean from the mean duration of 72 months.

4.5 Power Station Costs

It is widely believed that licensing delays are the sources of significant additional power station costs, although the amounts estimated vary over a range from $40 to $100 million per year. In addition, the effects of delays upon other cost components external to the power station can be large. Among the items potentially affected by a plant delay are the cost of

replacement energy and fuel costs due to the use of obsolete inefficient equipment which would otherwise be retired. In Figure 4.9 data are shown regarding the unit capacity costs of nuclear plants as a function of docket data. The general escalation of the nuclear plant costs with time is shown clearly, with a linear semi-logarithmic relationship fitting the single unit data rather well. The anamolously low costs of the early "turnkey" units may be misleading since these values tend less to reflect the true costs of these plants as much as they show the lossed suffered by the reactor vendors in order to establish a market for their products. The most important data are those for multi-unit replicate plants for which the average unit capacity costs are generally lower than those of their single-unit contemporaries.

A problem with the data of Figure 4.9 is that they are stated in current dollars, and one would wish to see them stated in constant dollars. An attempt at this transformation is presented in Figure 4.10 using the Handy-Whitman Index as a dollar-deflator. The striking result is that the apparent cost escalation seen in Figure 4.9 has disappeared. That is, for fuel load dates after 1975 there is no longer a discernable increasing cost trend in time.

The range of scatter in the post-1975 cost data can be attributed to the following factors:

1. Regional differences in costs of material labor, in labor productivity, and in design standards (e.g.,

seismic, cooling system, etc., requirements),

2. Use of national rather than regional deflator, and
3. The random effects of non-uniform public opposition to different plants.

Such a stabilization of real-costs for power plants would be expected as the nuclear power industry matures, and becomes more experienced in building plants; and as economies of scale realized by the later larger plants are largely eliminated by costly public safety and environmental protection design standards.

The capital costs of delay in bringing a plant on-line are shown more clearly in Figure 4.11 where a cost difference of approximately $150/kw is seen between plants of the same vintage delayed more than thirty months compared to those delayed for shorter times. This translates into a cost margin of $150 million per GWe plant, or approximately 30% of the cost of a plant. It is also seen that delayed plant costs is approximately the same.

Finally, in Figure 4.12 the ratio of actual to expected costs for U.S. nuclear plants is shown. It is seen that the multi-unit plants have been somewhat more successful in meeting their original cost goals than the single-unit plants, implying a benefit for a more efficient licensing process. While there is considerable scatter in the data it appears that the more recent plants have been more susceptible to uncontrolled cost growth than the early plants. However, at no time have the

builders of nuclear plants been spectacularly successful in bringing plants in on-time and on-budget. It is impossible to be precise regarding the contribution of individual factors in causing these cost overruns and schedule delays. However, from our work it is apparent that regulatory delay is a significant component, and one which is not being reduced.

4.6 French Licensing Experience

Most of the French LWR licensing experience has been confined to the Fessenheim 1 station (recently completed), and the stations which are currently being built. Based upon interviews with French licensing and utility personnel the only delay in the LWR program to-date which has been attributed to regulatory causes has arisen in connection with the Fessenheim 1 station and lasted approximately seven months (out of a total delay of 22 months). No associated cost estimate was available. The general expectation was that such delays would be much smaller in the future, and that those associated with Fessenheim 1 arose mainly from the need to consider an unusual number of generic issues since it was the first station of its kind.

4.7 Interpretation of the Results and Conclusions

We found in the analyses presented in previous sections typically a 44-month increase between the overall licensing and construction period of U.S. plants docketed in 1965 and that of the plants docketed in 1970.

On the average, the construction permit procedure is responsible for a 20-month increase and the period between construction permit and beginning of operation is responsible for a 24-month increase.

Although the licensing and construction period increases roughly linearly for docket dates from 1965 to 1970, the duration of the construction permit procedure shows a peak centered on the docket date of 1970 before leveling off at values higher than those prevailing before the duration-growth was observed. This peaking of the construction permit procedure length can be attributed to the implementation of the AEC's revised Environmental Statement regulations of December 1971 (Ref. 24), following the Calvert Cliffs decision. According to these new regulations, AEC extended the scope of its review of environmental impacts from only radiological issues to all types of environmental impacts (thermal, biological, etc.). It was decided that "all construction permits and operating licenses [would] be conditioned on observance of environmental protection requirements" and that "this condition [would] be included in licenses previously issued which [did] not have the condition" (Ref. 25). This implied back-fitting measures that affected all of the applications in the various stages of the licensing process at that time and also most of the reactors in operation. This explains why, although (as can be seen in Figure 4.3) the new regulations today lengthen the construction permit procedure by a 7-month period, some applications docketed in the years 1968, 69, 70 and 71 were delayed for much longer periods (as much as 43 months). The Calvert Cliffs decision affected 103 nuclear power reactors then in operation, under construction, or under review in the licensing process. Of the 88 reactors in the

licensing process, about half were either in the hearing stage or nearing completion of AEC review, and the remaining applications were in various stages of review, ranging from those recently filed to those six months from normal review completion (Ref. 26).

During the year 1971, 36 licenses with construction permits or operating licenses for 53 reactors were required to submit information as to why the permit or license should not be suspended pending completion of broadened environmental reviews by the AEC. Then, in November and December 1971, the AEC determined that construction activities should be partially suspended at five sites, involving eitht plants, pending completion of the NEPA review and that the continuation of construction or operation at the other 45 plants was approved (Ref. 26).

All told, of the 23 power reactors in an operational state (not all with operating licenses), only 12 plants were exempt from any NEPA review of environmental effects (Ref. 27).

Clearly, most of the reactors affected by the decision were in opearation or in the last stages of the licensing process. With respect to this last point, it must be noticed that delays affecting a nuclear powerplant nearing completion of construction induce particularly high costs, of the order of $70 million per year of delay in 1973 (Ref. 28).

The effects of the Calvert Cliffs decision on the durations of the AEC review and on the period between ACRS Action and ASLB Approval is seen in Figure 4.5; Figure 4.6 shows a less uniform behavior of the licensing duration at the hearing stage,

certainly corresponding to a greater importance of local particularisms and socio-political conditions at this level.

The length of time for construction permit issuance to operating license issuance depends on the duration of the NRC evaluation and eventually on that of hearings, but also on the effective construction period length. Therefore, regulatory delays can less easily be identified in Figure 4.8 than in earlier licensing stages.

We note that the 24-month duration increase shown in Figure 4.8 from 1965 to 1971 can be attributed to longer construction periods corresponding to technological changes (such as the increase of the size of the commercial nuclear power plants), and also to the effect of the Calvert Cliffs decision on those plants which were in construction in 1970. It is also seen in recent years that the importance of uncontrolled costs has increased as the actual expenditures for power stations have tended to exceed original estimates by increasingly greater amounts.

We can then conclude that following the NEPA and the Calvert Cliffs decision, the implementation of new regulations has had, in terms of delays, very improtant temporary consequences because of the requirements for retroactive measures. They have also had permanent effects, mainly on the nature and duration of the construction permit procedure.

Figure 4.1 - Number of Plants Operated or in the Siting Process

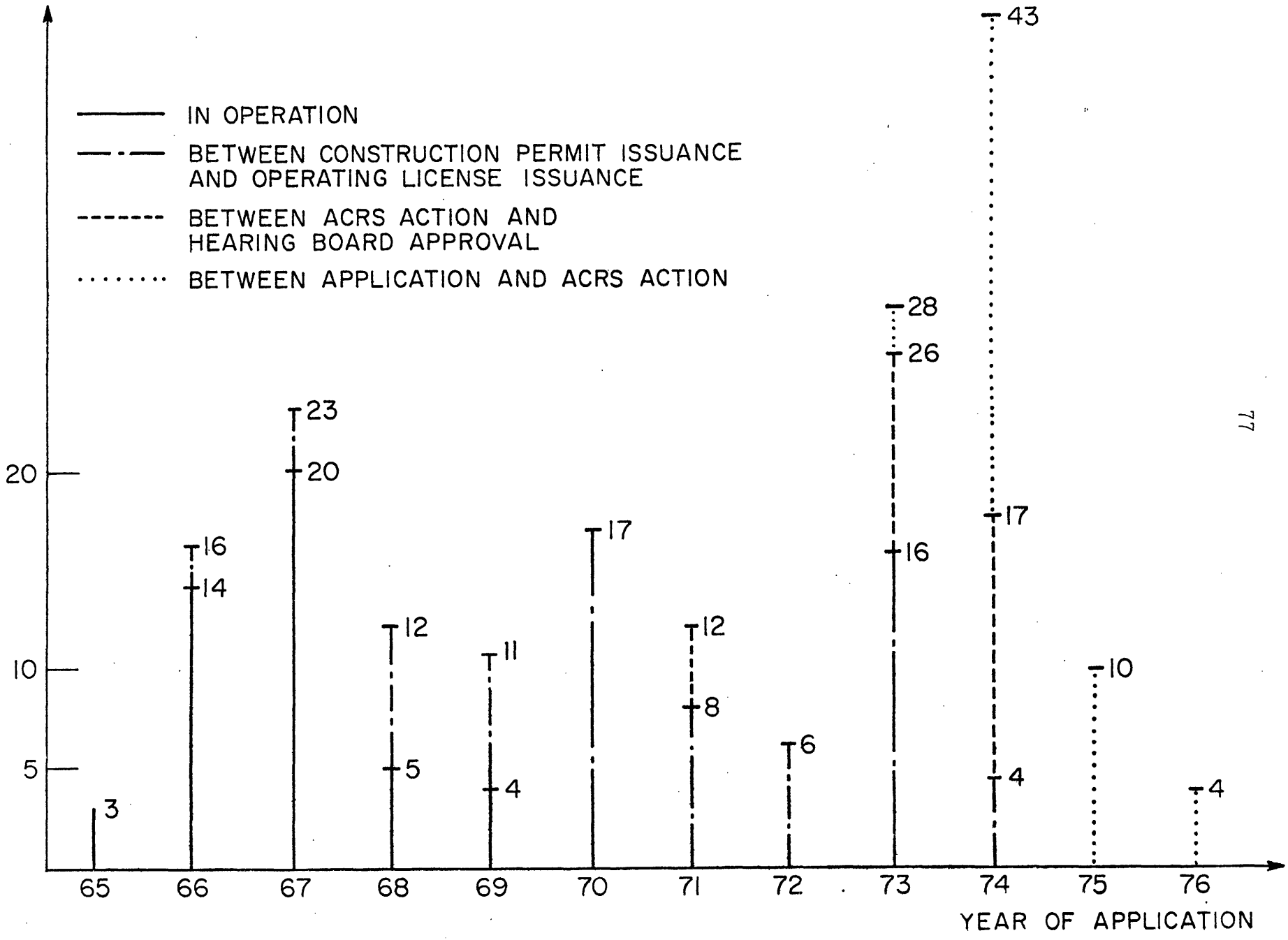


Figure 4.2 - Average Period from Application to Operating License

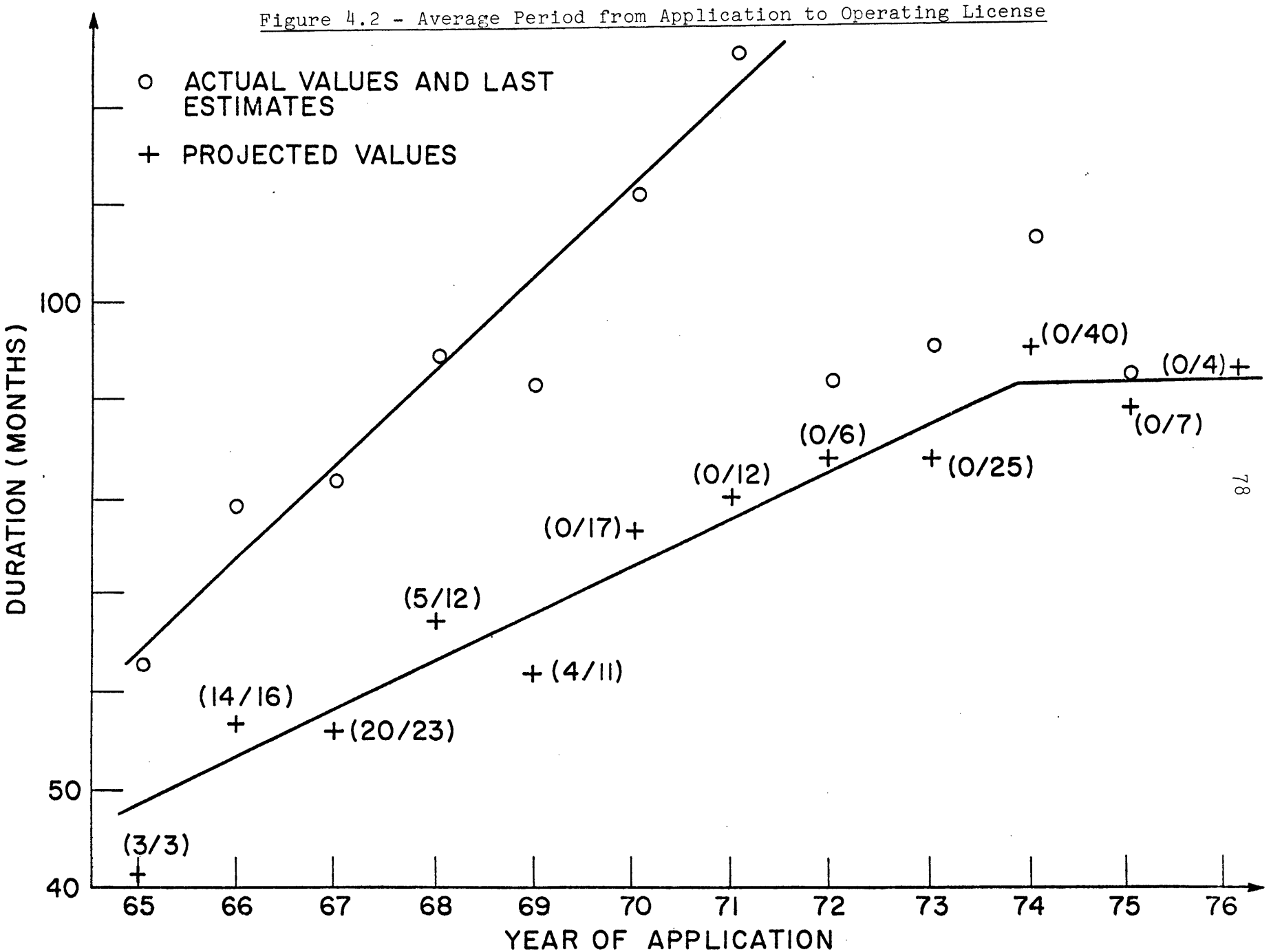


Figure 4.3 - Interval Between Docket Date and CP Date

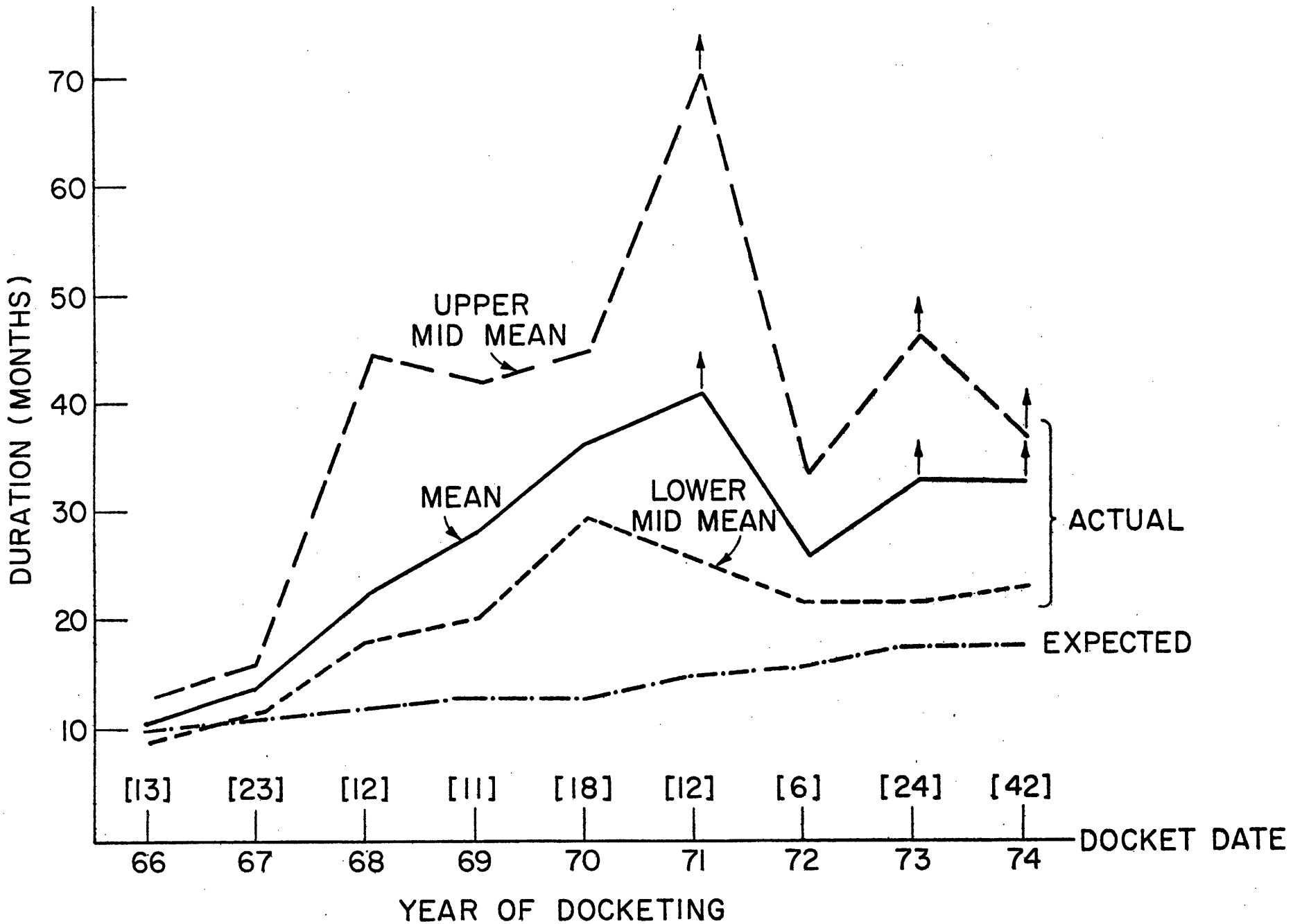


Figure 4.4 - Construction Permit Licensing Duration Discounted for Deferrals by the Utility

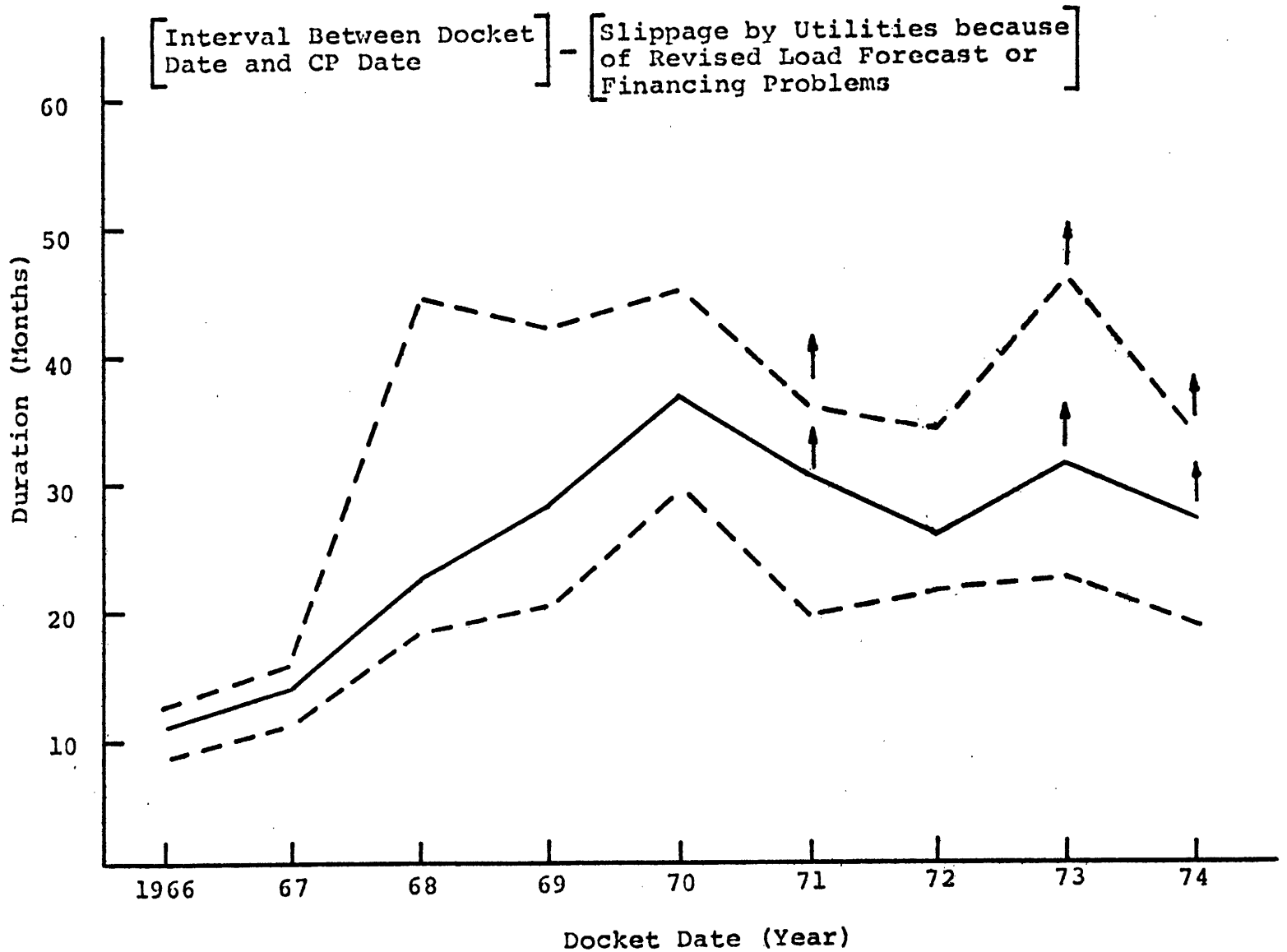


Figure 4.5 - Period from Application to ACRS Action

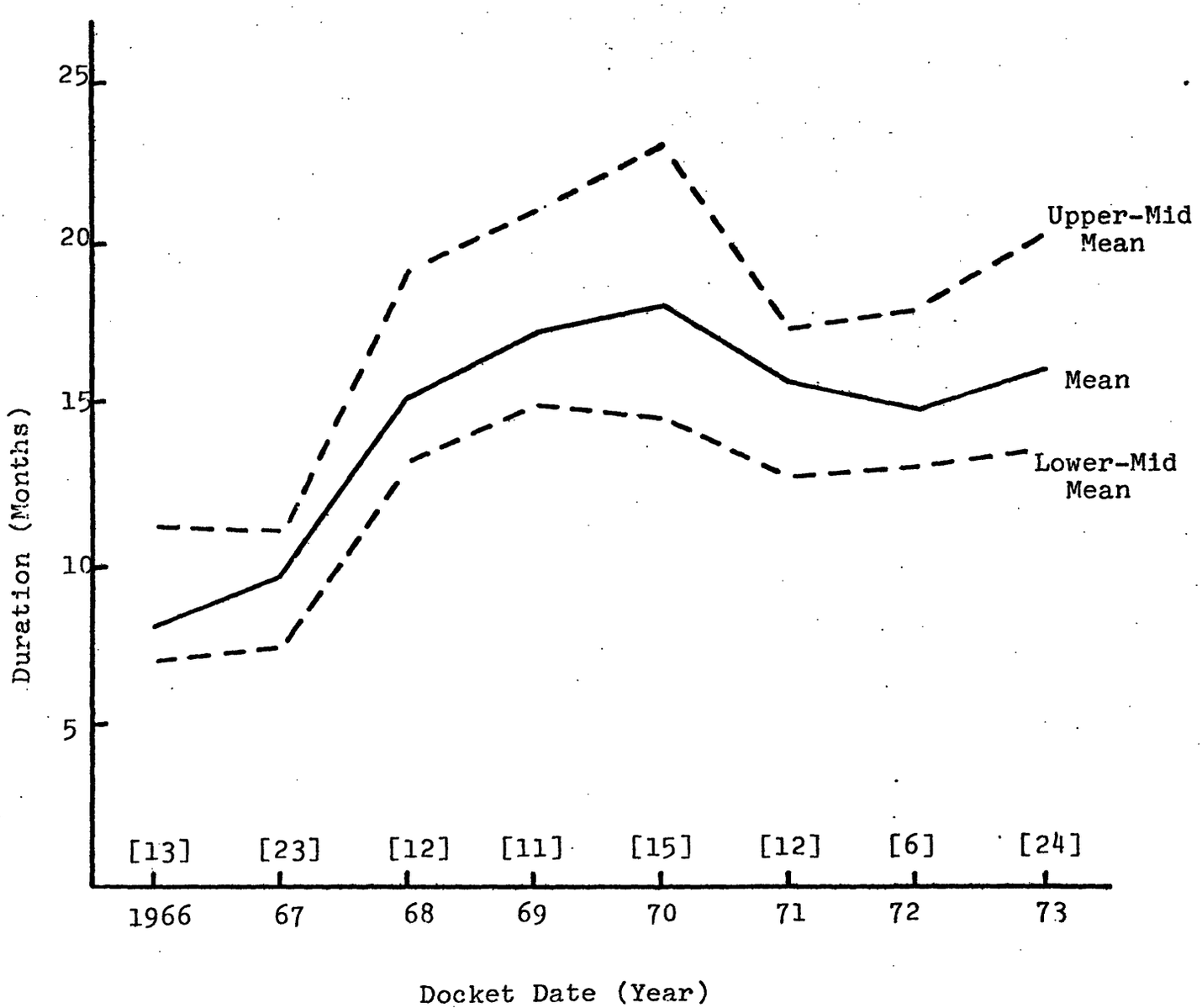


Figure 4.6 - Period from ACRS Action to Hearing Board Approval

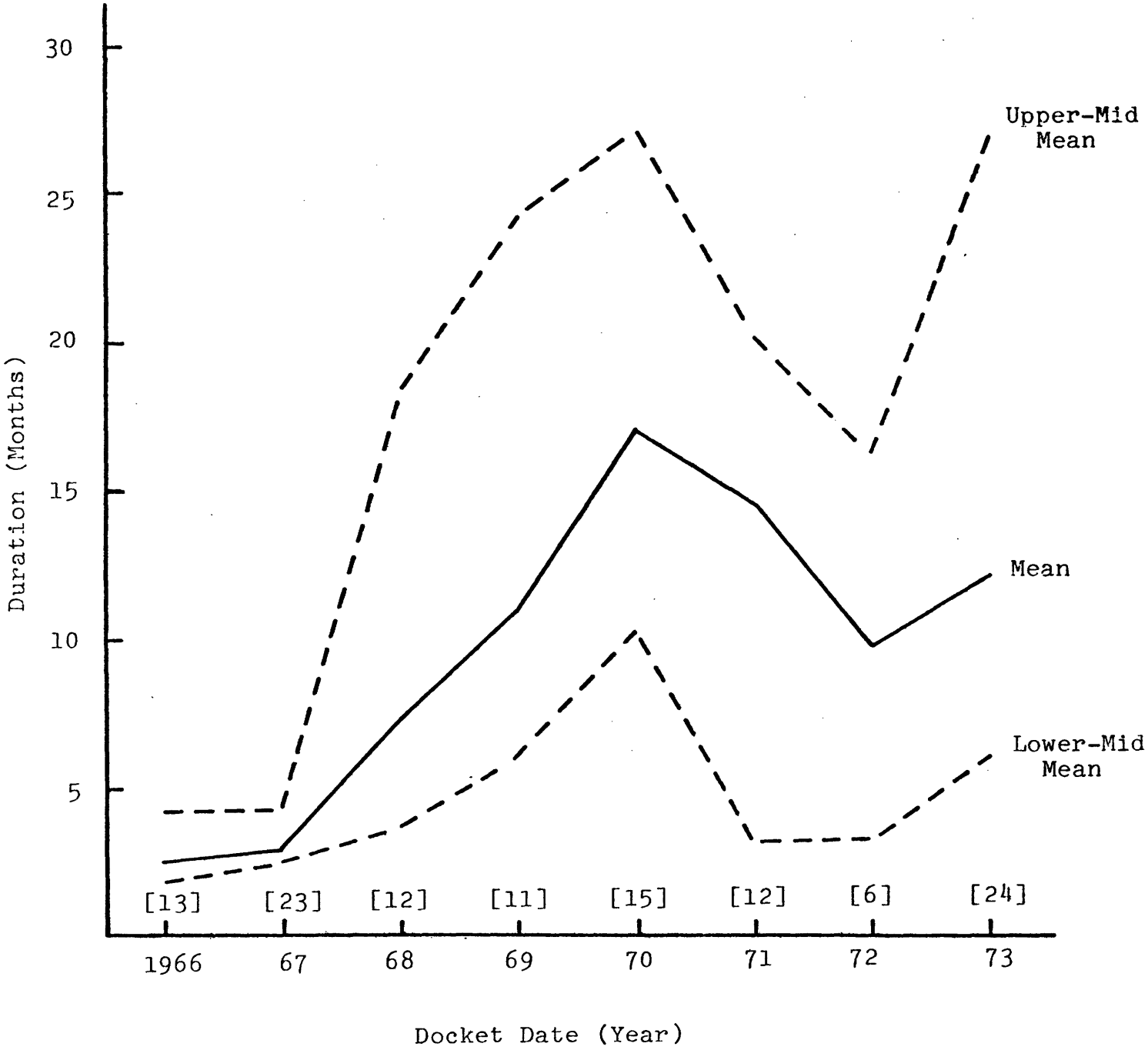


Figure 4.7 - Cumulative Mean CP Licensing Intervals, Docket Date to ACRS Action, and ACRS Action to CP Issurance as a Function of Docket Date

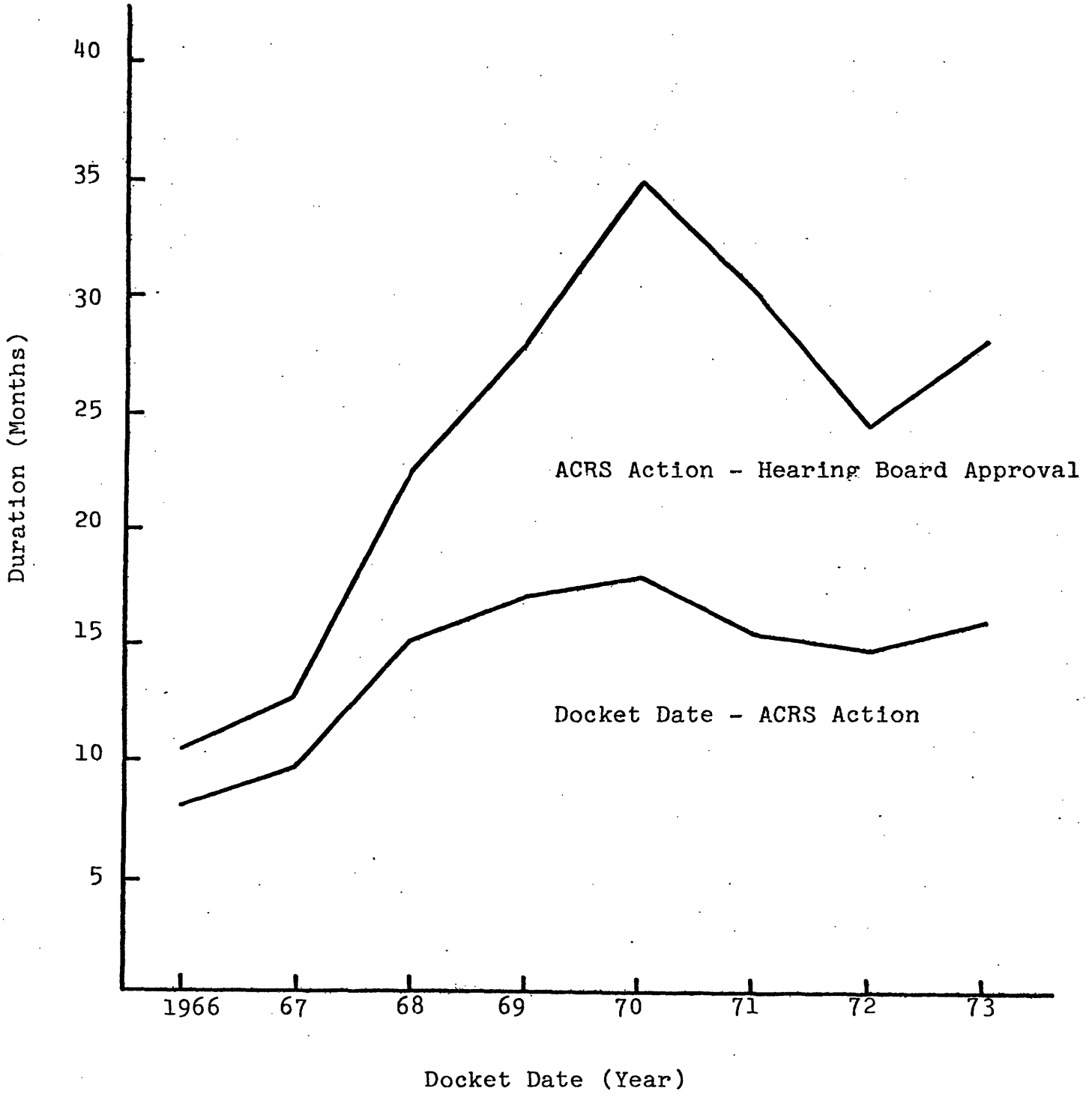


Figure 4.8 - Length of Period from Construction Permit to Operating License as a Function of Docket Date

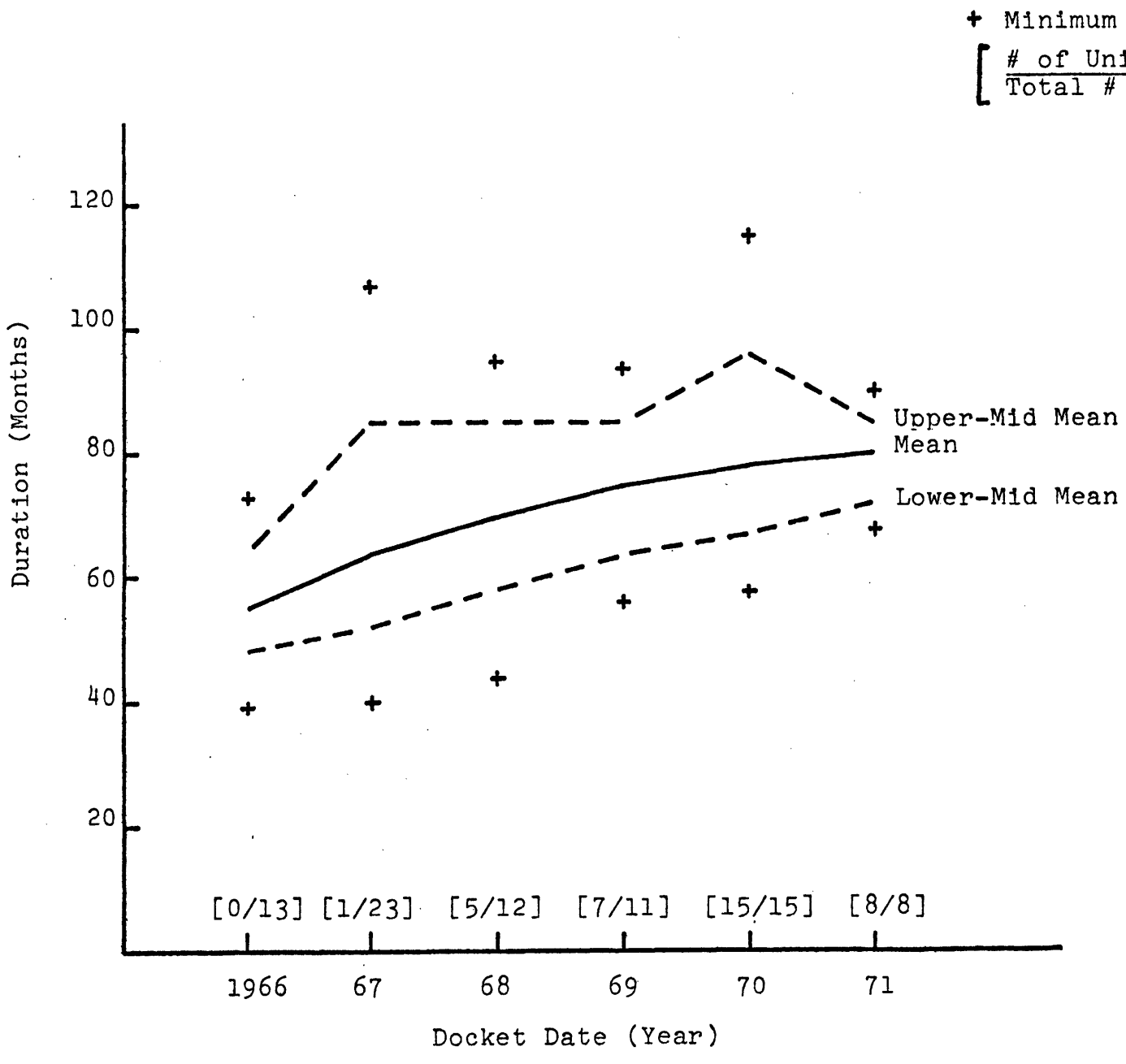


Figure 4.9 - Unit Capacity Costs of Nuclear Plants as a Function of Docket Date (Including IDC)

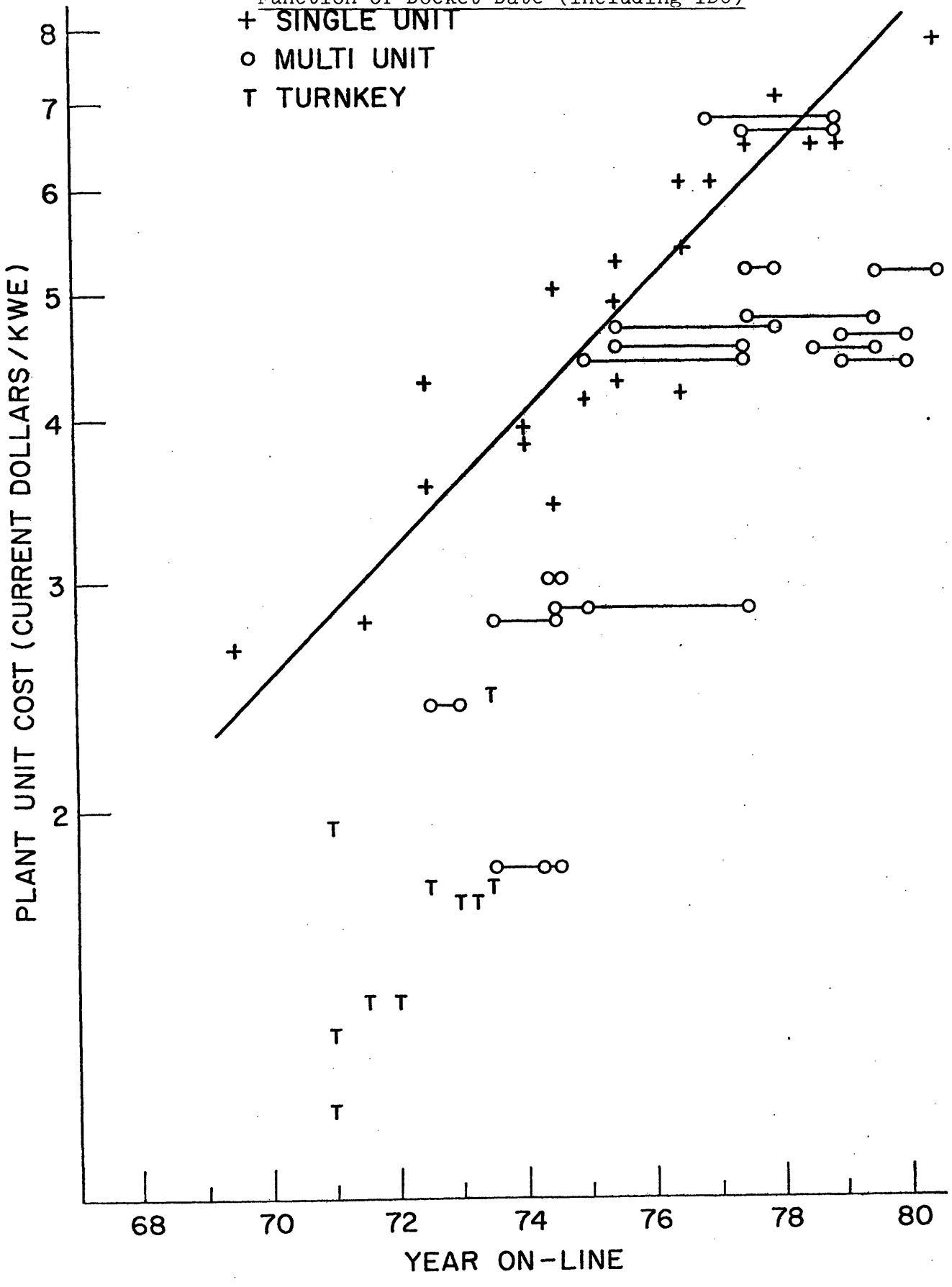


Figure 4.10 - Data of Fig. 4.9 Stated in Constant 1976 Dollars

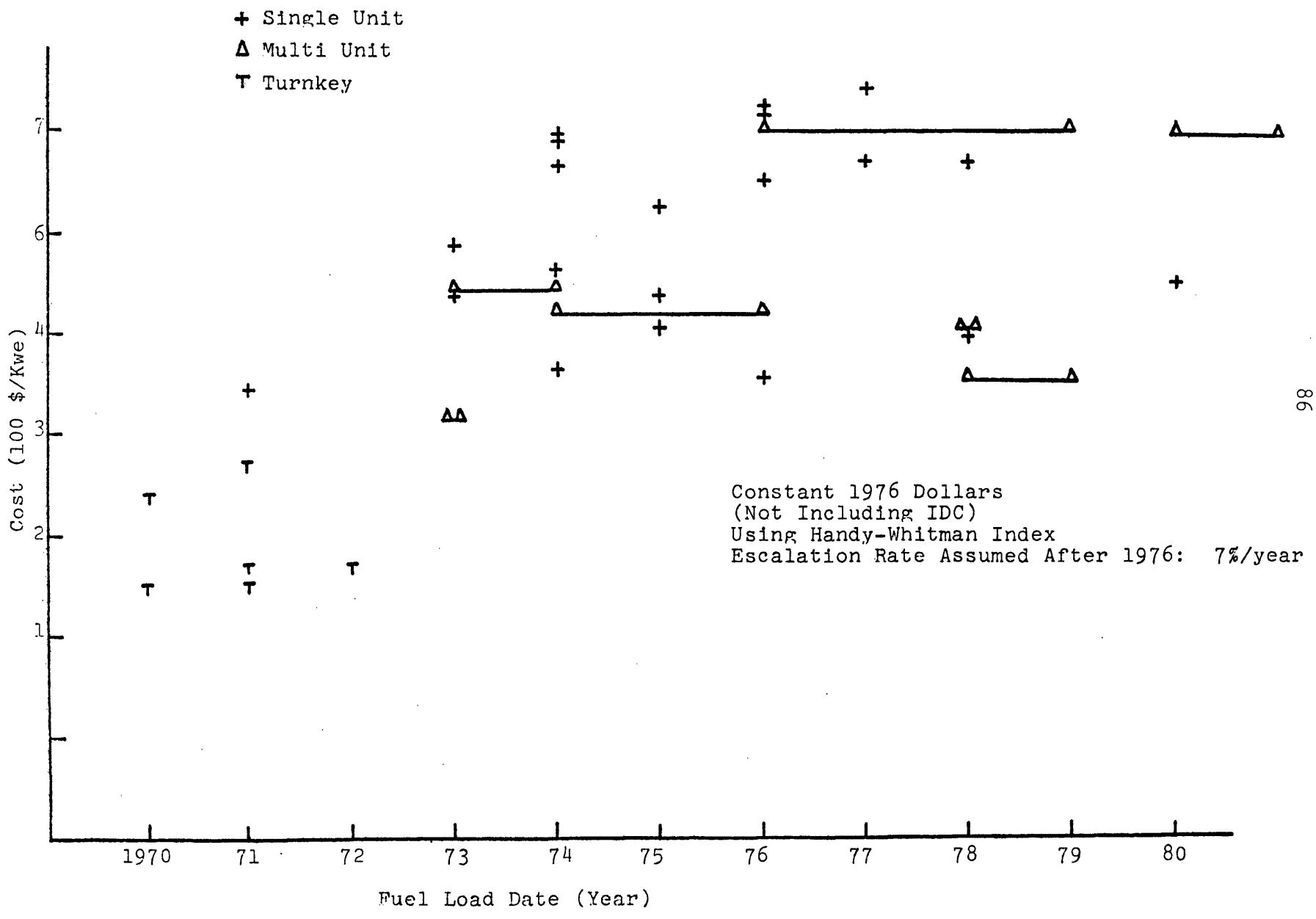


Figure 4.11 - Power Plant Unit Costs as a Function of Operation Schedule Slippage

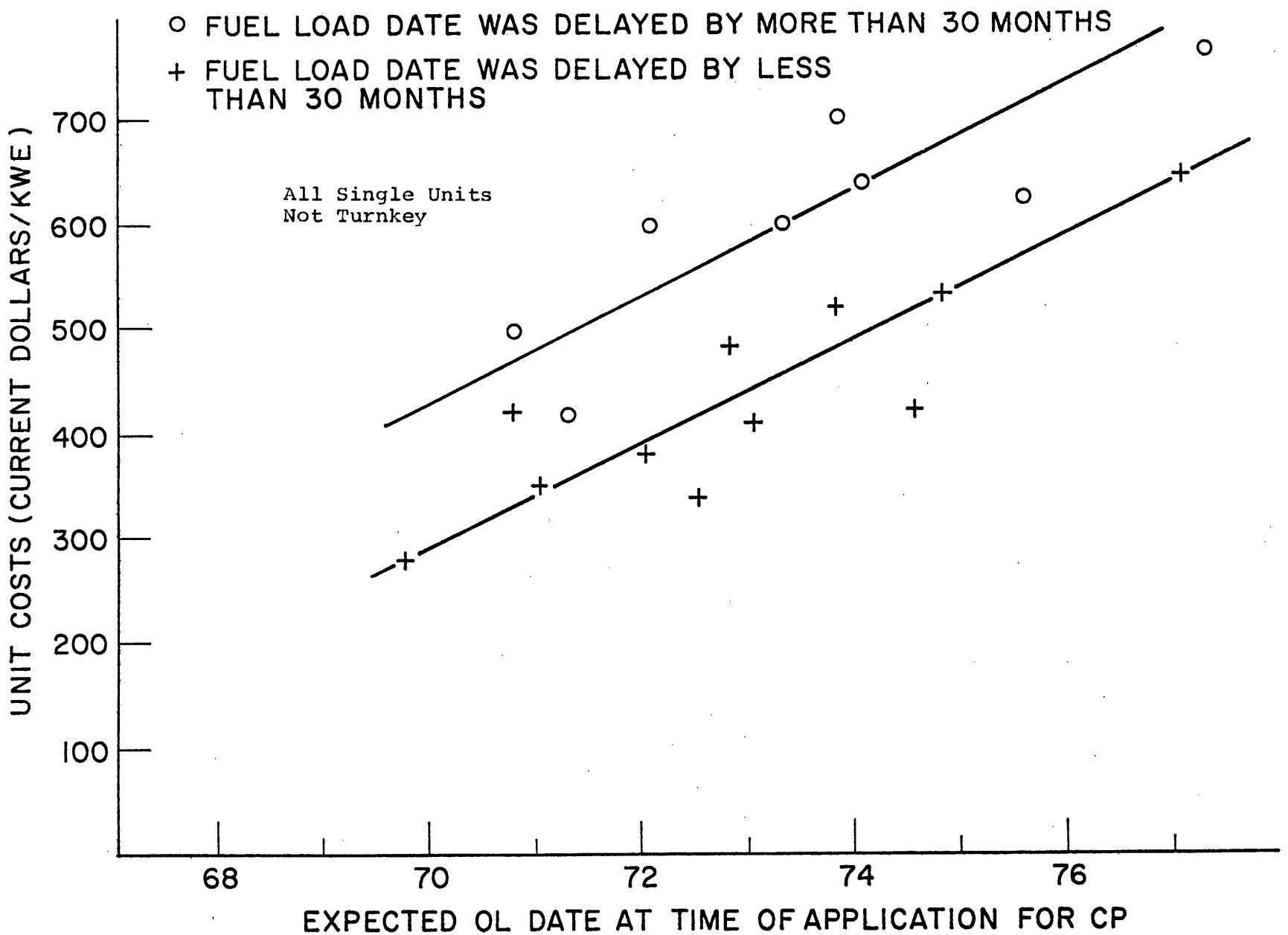
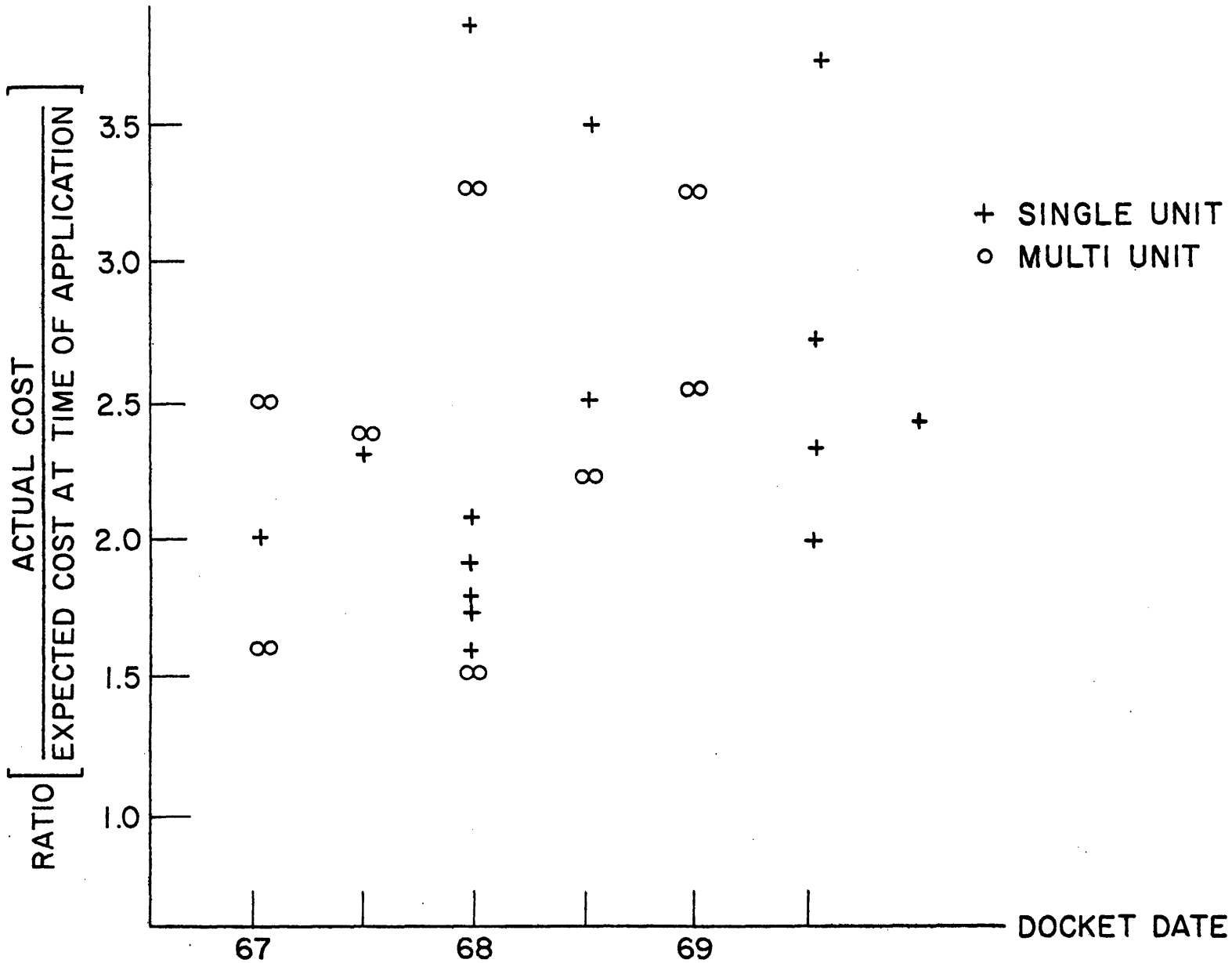


Figure 4.12 - The Ratio of Actual to Anticipated Costs as a Function of Plant Docket Date



5. COMPARISONS AND CONCLUSIONS

There are important differences in the French and United States political systems and societies which result in their separate nuclear regulatory systems also being different. It is important to make note of these differences since they tend to inhibit the ability of either system to adopt desireable features of the other.

5.1 Political and Legal Background

To a strong degree the different nuclear regulatory systems are products of the different national political systems. The French government is highly centralized (since the days of the Kings and Napoleon), with a ministerial executive system (which is not directly accountable to the people), and with several important political parties which are ideologically distinct. The primary means of citizen participation in the government is through the political parties, by means of party discipline - for the party(ies) in power - influencing ministerial and governmental decisions and policies. Thus, polictical issues are resolved through competition between political parties for popular support, and through competition between elements within the parties to influence party policies. The result is to insulate the processes of governmental implementation of policy from political interference. The political component becomes important at the policy formulation level. It also results that the main avenue of redress for a private party who is not satisfied by a governmental action is through

attempting to change - at the ministerial level - the policy which lead to the action.

The United States has a system of strong governmental units at the local, state and federal levels with responsibilities for vital social functions divided among them. Generally, these agencies have individual mandates which are not reconciled in terms of a centrally agreed-upon policy. Thus, in many matters agencies from all of the governmental levels may be involved, sometimes with overlapping areas of interests and differing policies. The American system is also structured so that appeals by private parties who disagree with governmental actions are often possible at a succession of administrative and then judicial levels. Consequently, the approval of many more governmental actors is potentially required in the American system for projects requiring governmental approvals than in the French. As a correlary the time required to obtain definitive decisions in the American process can be much longer.

Another important difference is that French laws tend not to be directly concerned with the technical criteria of governmental policies or actions which the laws may require to be implemented. In other words, the goal of the policy or action will tend to be determined in the French law, but the means of its implementation and specific technical standards tend to be left in the hands of the responsible ministry. Thus, legal objections in the courts to the implementation of a policy are generally confined to whether the formal procedure specified in

a law has been followed correctly; with questions regarding the technical quality or correctness of the actions under objection being outside the court's scope of review.

In the United States the same point is often also true, but there are also laws which specify the technical criteria or which provide detailed guidance regarding how the policy will be executed. Examples of such laws are the National Environmental Policy Act of 1969, the so-called "Delaney Amendment" regarding carcinogens in foods, and the Surface Mining Control and Reclamation Act of 1977. The latter class of laws allows for judicial review of both the form and the technical substance of governmental implementation actions. The existence of this set of laws tends to imply a lower level of trust being invested in the U.S. bureaucracy than in the French. In the case of nuclear power station licensing this latter category of basis of appeal has been very important in allowing individual citizens to participate in the licensing process. In France this avenue is largely unavailable.

Finally, it must be noted that the degree to which governmental actions are potentially exposed to public scrutiny is much greater in the United States than in France. The federal Freedom of Information Act and many similar state "Sunshine Laws" have made the workings of government much more available to review by the individual citizen (although the claim is heard that concealment of governmental actions is still widely practiced)

who has the inclination and resources to exercise the powers which they provide. In France, by contrast, the public has no right to review the internal workings of the government. The memoranda, reports, and in some cases, the identities of the officials involved in administrative decisions are protected as governmental secrets. The claim is made that such confidentiality stimulates an honest exchange of dissenting opinions within the government, and that it tends to avoid creating needless concern among the people regarding the substance of the decisions being made on their behalf. Consequently, in the area of nuclear power licensing, there is considerably less public knowledge of the technical substance of safety and environmental protection decisions being considered by the government, and there is also less ability by those outside the government to influence these decisions. In summary, the French system operates on the assumption that some matters do not lend themselves well to resolution through participatory democracy, but rather should be decided by technically competent persons of integrity who will act for the benefit of society.

In nuclear power safety and licensing the American practice has been to deny to the government the degree of public trust which is necessary for the functioning of the French system. It requires more frequent and visible demonstrations of the technical correctness of regulatory decisions, and allows much more easily for challenges by the public of such decisions.

5.2 Methods of Compromising Conflicting Societal Interests

A basic function of government is that of providing a method for compromising conflicting social goals (i.e. maintenance of economic growth and the simultaneous protections of environmental values). It is apparent from the discussion of Sections 2 and 3 that in the area of electric power generation the methods for doing this in France and the United States are very different.

In France, the national electric economy is planned and controlled by the national government. By virtue of its exclusive ownership of E.D.F., the identity of the government with the utility company is complete. The decision of how much capacity will be built and what kind is exclusively under the control of the government. Thus, nuclear power safety and licensing regulatory decisions amount to being made in the context of the established desire for accomplishment of a definite national electric generation expansion goal. The economic justification for a power station is an accomplished fact before the first consideration of environmental issues relative to a station at a specific site occurs. Consequently, the need for a project at a particular site is seldom considered (unless severe unanticipated safety or environmental hazards are discovered) during the power station construction/permit licensing sequence. Rather, the licensing process consists of considering what design changes are required in order to assure a reasonable degree of public and environmental protection given that the

project will go forward. Since the national government is responsible for both economic health and environmental protection, the balancing of these conflicting goals is accomplished in a simple, consistent, predictable, and speedy manner in the French system. Consequently the system is seen to be very efficient.

In the United States system there is no national electric generation plan (much less a national energy plan); there are generally no statewide electric energy plans; and even the statements of national goals and expectations in this area have been highly erratic in recent history. Effectively, promotion of environmental and public safety values has become a direct (i.e. mandated by legislation and litigation) governmental responsibility, while to a much larger degree, promotion of economic growth remains an indirect governmental task. In the latter area the efforts of a particular administration are determined much more by political considerations than by legal incentives. Thus, the U.S. system does not provide a simple mechanism so that economic and environmental values can be accommodated in a consistent and predictable fashion. In regulating any electric power project some balancing of such conflicting goals is inescapable. However, in the American system the outcome for a particular project will depend upon the complex interaction of several private and public, local, regional and national actors. The resulting environmental vs. economic resolutions vary over a broad spectrum, and appear to follow no simple logic.

While many governmental units have obligations to promote environmental and public safety goals, no important governmental agency has a similar role of promoting economic stimulation goals. More importantly, no single governmental agency in the usual United States nuclear plant licensing process has responsibility for balancing economic priorities against those of safety and the environment, and no widely accepted method exists for the performance of such a balance using a free market mechanism in the absence of an explicit balancing within the government.

Regarding regulation of new power generating plants there exists the popular belief in the United States that the decision regarding what technology will be used is made in accordance with classical free-market economics with the government(s) providing a relatively small perturbation in its role of protecting non-economic values. Consequently the need for a balancing of economic and non-economic priorities is seen to be unimportant since the latter issues involve relatively small costs. From the discussion in Section 5.5 it is seen that this belief is invalid. The costs of nuclear power regulation are significant, and the role of government in determining the nature of the technology to be used is pervasive. Therefore the need for an agency empowered to balance both classes of interests should appropraitely be considered.

5.3 Separation of Nuclear Power Political and Technical Issues

It is seen that the French system provides for a division

of the political and technical issues relating to nuclear power so that each class of issues is considered separately. The political issues (i.e. how much new capacity is needed, what technology is most economical, what sites should be considered for power station use) are treated in the formulation of the national electric energy plan. This process is eventually carried out at the top levels of the government (including E.D.F.), and is highly influenced by the politics of the party(ies) in power. Technical issues (i.e. what sort of containment building design is needed) are resolved in the licensing process. The licensing process is thereby protected from the chaos which results from having to consider political questions - that is those upon which there is broad popular disagreement and interest.

The American licensing process is required - partly through default on the parts of other governmental sectors - to consider both political and technical issues.[1] It is poorly-suited for former task and well-suited for the latter. The absence of well-established policies regarding the level of need for and the national acceptability of nuclear power forces such issues into the licensing process of each individual plant since they currently are not resolved at a more general level as purely political questions.

---

[1]We recognize the contribution to the clarification of these issues by Professor A. W. Murphy, Columbia University Law School, through unpublished communications during the course of this project.

This has the effect of encumbering what should be straightforward technical review with questions which are not technical, and which it can never resolve satisfactory in a technical review. The consequences of this are that the licensing process becomes greatly complicated and delayed, and that - through publicity of licensing processes - the general public becomes greatly confused and alarmed because the political debate regarding the desirability of nuclear power becomes complicated by the introduction of a mass of technical questions which the public is unable to evaluate. An important result of this latter confusion is that it becomes more difficult to achieve the consensus required for resolution of the political issues, and consequently it continues to be impossible to separate political and technical questions in the licensing process.

5.4 The Climate of Regulation

As is implied in Section 2 the regulatory climate in France has a strong element of mutual cooperation, personal trust, and spirit of reasonable compromise between the equipment vendors, the utility company, and the governmental regulators. This arises from several factors:

1. The numbers of personnel and organizations involved are relatively few, and with low turnover - permitting personal relationships to arise through long-term association,

2. Effectively all of the actors from the various organizations are engaged in a central governmental plan to install a desired level of capacity at a desired level of safety,

3. The technical judgement of the staff is used in evaluating proposed designs, and very few previously prescribed judgemental criteria are employed, and

4. The detailed licensing process is largely immune from non-governmental review and criticism.

Regarding the objectivity of the French process, the claim is made that total responsibility for the adequacy of the design of a proposed power station and the entire burden of proof of that adequacy rests with E.D.F.; and that the function of the governmental review is simply to determine whether the proposed design is acceptable. However, it appears to be inevitable in a regulatory situation involving negotiation between the utility and the regulators regarding what is acceptable, with some cooperation being necessary in arriving at a mutually acceptable design, that some sharing of responsibility by all parties must occur. This last observation has been made - we think validly - regarding the U.S. licensing process. In the United States this provides an incentive for the regulatory staff to make conservative decisions, since doing so reduces the risk of being partially responsible in the future for a safety or environmental embarassment. It should be noted that in the U.S. the same disclaimer of responsibility for approved design is made as in France.

In France, once a design acceptable to the governmental regulators is agreed upon, the only remaining step is for the Minister for Industry and Research to give his approval to the design upon the recommendation of his staff who have previously approved it. The minister generally has no independent expertise in such matters, and there exist in France no uninvolved organizations which can provide competent independent judgement to him. Thus, there is no convenient mechanism for independent review of regulatory decisions once they have been made. This accounts for much of the efficiency of the French system.

In the United States the regulatory climate is adverserial, legalistic, cumbersome and sometimes acrimonious. There are several reasons for this:

1. The numbers of personnel and organizations involved nationally are large - requiring more rigidly formalized procedures,
2. In attempting to standardize the licensing process a large literature of judgemental criteria has been developed consisting of congressional legislation, federal regulations, individual agency guidelines, and judicial rulings - all of which must be respected by regulatory decision-makers,

3. There are no national or state-level electric energy development plans which become incorporated into the licensing review as judgemental criteria, and

4. Initial regulatory decisions are subject to subsequent administrative and judicial reviews, and may be rendered moot by the actions of other uncoordinated agencies,

5. Access to the process by interested non-governmental parties is relatively easy,

6. The process involves consideration of issues which are basically political (e.g., the need for new generating capacity), which in other national regulatory systems are kept out of the regulatory process and which are resolved generically through the political process,

7. The process often requires consideration of generic technical issues on a plant-by-plant basis, so that a specific plant-related decision acquires importance far beyond the single plant being licensed, and

8. A climate exists of public distrust of its governmental agencies and of large private organizations which has become translated into a political atmosphere which rewards caution and punishes risk-taking decisions by politicians and by governmental officials.

All of these factors work to reduce the efficiency of the process since they inhibit the ability of those involved to arrive at reasonable, speedy, definitive decisions. For the individual regulatory staff member this climate creates incentives to make safety and environmental protection decisions which are conservative but expensive, but which are less likely to be criticized in subsequent reviews by parties other than the utility. The frustrations of utility companies in trying to work in this atmosphere are well known.

An aspect unique to the American regulatory system is the potential importance of the individual intervenor. The argument is made that the system needs to be made more open to public participation since in attempting to resolve technical questions the imbalance of resources in favor of the license applicant makes it very difficult for a concerned private party to participate effectively. A proposed means for resolution of this is governmental funding for intervenors in licensing reviews. This argument has some validity, since it is actually very difficult for a private party to approach the level of knowledge, etc., required to criticize proposed nuclear plant designs. However, a more important aspect of private intervention in licensing is that it permits political action to be taken against the use of nuclear power by the mechanism of introducing delay into the process as licensing decisions are appealed within governmental agencies and in the courts. This

latter use of the intervention process by opponents of nuclear power results in the greater intermingling of political and technical questions in reactor licensing. Such intervention consists of the pursuit of political goals (i.e. suppressing use of nuclear power) under the guise of pursuing technical questions. This occurs in part because satisfactory alternative forums of pursuing such political goals as stopping nuclear power are not conveniently available in the United States. The result is to exacerbate the degree of divisiveness in some licensing proceedings, and to make more difficult and time-consuming the resolution of purely technical questions.

While modifications of the United States process which could improve efficiency are clear by inference from the French process, it is not apparent how such modifications could be implemented politically, or that they would be acceptable to the American public.

5.5 Summary

From the comparison of French and United States nuclear power station licensing practices it is seen that the French system is relatively efficient and authoritarian. The United States system is much more cumbersome and inefficient; however, it is also more open to direct participation by individual citizens. The origins of these differences appear to lie in fundamental differences between the governmental systems of the two societies, and it is

unclear that either system could be modified easily to incorporate features of the other which may be viewed as desirable. An important consideration is that the United States system imposes a heavy economic price on its society in terms of the additional costs of pursuing nuclear power regulation in the American way. Whether it is wise to continue in this fashion is a question which has largely been ignored until recently, and is one which deserves renewed attention.

REFERENCES

(1) Jean-Claude Lebreton, Exploiting the Economic Advantages of Nuclear Power, (Nuclear Engineering International, December, 1976.)

(2) E.D.F. data, February, 1977.

(3) Jean-Claude Levy, Benefits of Concentrating NSSS Manufacture in One Company, (Nuclear Engineering International, December, 1976.)

(4) Governmental Publication: Localisation des Centrales Nucleaires, (November, 1974.)

(5) Echauffement des Eaux pour les Centrales Nucleaires, (E.D.F., Direction de l'Equipement: Dossier E, December, 1974.)

(6) M. Khalanski, Incidences Ecologiques de la Refrigeration des Centrales Nucleaires en Circuit Ouvert, (E.D.F., Direction des Etudes et Recherches, April, 1975.)

(7) G. Merle, Consequences Ecologiques de l'Utilisation du Chlore dans les Centrales Implantees en Bord de Mer ou en Milieu Estuarien, (E.D.F., Direction des Etudes et Recherches, March, 1975.)

(8) See for instance: Mise en Valeur des Rejets Thermiques de la Centrale de St. Laurent des Eaux, (E.21.bis), (E.D.F., Direction de l'Equipement, September, 1976.)

(9) Sites Nucleaires - Centrales PWR, (E.D.F., Direction de l'Equipement, (Chapter IV and V), 1976.)

References continued

(10) See for instance: R. Schaeffer, Les Reconcentrations Ecologiques des Radioelements Rejectes par l'Industrie Nucleaire, (E.D.F., Direction de l'Equipement, (F. 67).)

(11) Jean Mattei, Le Bruit et l'Environnement, and Action en Vue de la Reduction des Niveaux Sonores, (E.D.F., Direction des Etudes et Recherches, 1971, and 1974.)

(12) Sites Nucleaires - Centrales PWR, (E.D.F., Direction de l'Equipement, (Chapter VII), 1976.)

(13) J. Jacquet and G. Tschirhart, Effects de Taille des Rejets de Chaleur dans l'Atmosphere. Incidences sur le Choix des Sites des Centrales, (E.D.F., Direction des Etudes et Recherches, March, 1974.)

(14) J. Servant, International Conference on Nuclear Energy - Salzbourg, May 2-13, 1977.

(15) Letter from Mr. LeQuino (Ministry of Industry and Research) of May 11, 1977.

(16) Une Centrale Nucleaire dans la Commune, (Ministere de l'Industrie et de la Recherche.)

(17) Amenagement de la Procedure d'Instruction Prealable a la Declaration d'Utilite Publique des Centrales Thermiques Classiques ou Nucleaires, (Ministere de l'Industrie et de la Recherche, Circulaire No. 76-72 du 24 Aout, 1976.)

References continued

(18) P. Candes (CEA), Practice and Experience of Safety in Nuclear Plant Siting in France, (Conference on Nuclear Plant Siting - August 25-28, 1974, Transactions of the American Nuclear Society, Supplement to Volume 19.)

(19) John W. Stetkar, On the Design, Simulation and Policy Implications of Total Energy Systems, (MIT Environmental Engineering Thesis, Chapter 8, 1976.)

(20) Annual Report, 1975, (U.S. Nuclear Regulatory Commission.)

(21) Nuclear Power Plant Delays in New England, (Report of the Federal Regional Council of New England, November, 1976.)

(22) Siting of Nuclear Facilities, (Proceedings of a Symposium organized by the IAESA and NEA, Vienna, December 9-13, 1974.)

(23) Irvin C. Bupp, Trends in Light Water Reactor Capital Costs in the U.S.: Causes and Consequences, (Center for Policy Alternatives, M.I.T., December, 1974.)

(24) Amendments to 10 CRF Part 50 Appendix D, "Licensing of Production and Utilization Facilities", (Federal Register of December 4, 1971.)

(25) Annual Report to Congress of the Atomic Energy Commission for 1970.

(26) Annual Report to Congress of the Atomic Energy Commission for 1970.

References continued

(27) P.F. Gustafson, Experience in Assessing Acceptability of Nuclear Sites Selected by the Utility Industry in the U.S.A., 1971-1974, Proceedings of the IAEA and NEA Vienna Symposium of December 9-13, 1974 (page 220).

(28) Northeast Utilities Report on AEC Regulatory Effect on Cost and Schedule of Nuclear Power Stations, December, 1973.

(29) Same as (23).