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An Analysis of the Influence of Nuclear Reactor Safety Philosophy on the Growth of the Civilian Nuclear Power Industry in the United States

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THE INFLUENCE OF NUCLEAR REACTOR SAFETY PHILOSOPHY
ON THE GROWTH OF
THE CIVILIAN NUCLEAR POWER INDUSTRY
IN THE
UNITED STATES

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Foreword

The observations and conclusions presented in this paper are the personal views of the author and they are not necessarily concurred in by the United States Atomic Energy Commission.

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I. STATEMENT OF THE PROBLEM

A. The Problem

Experience during and after World War II with the atomic and the hydrogen bombs left a definite and intended cloak of secrecy around the concept of atomic power. Words such as 'Nagasaki' and 'Hiroshima' would cause most people at once to conjure up horrible thoughts of devastation and destruction, and to recall thousands of deaths from blast, thermal, and radiation effects. The tremendous impact from a military use of atomic energy left a vivid impression in the minds of many people. During the early post-war years very few settled their thinking to that concerning untouched potential uses of the power in the atom.

By 1949, the Russians, with the help of spies David Greenglass, Klaus Fuchs, and others, had exploded their first atomic bomb. This news also set off a renewed emphasis on war uses of atomic power, and stimulated further development of the more powerful hydrogen bomb. Not until 1954 did federal enabling legislation provide a basis for industry to begin to demonstrate controlled nuclear reactions as part of an integrated electric power economy.

There was much controversy over the new power source, and much opposition to it. In the past decade there have been many loud claims and arguments from spokesmen of the coal and fossil-fuel industries, and from organized labor. Almost all of the opposition came from those groups whose primary area of interest appeared to be challenged by a new development.

Those who spoke for the fossil-fuel industries seem to have feared their fuel might be superseded and they would lose their business; and those who spoke for labor surely must have been concerned that a new technology might bring some unemployment for them.

United States Government policy as stated in the Atomic Energy Act of 1954 was declared to be that the development, control, and use of atomic energy should be directed toward the improvement of the general welfare and an increase in living standards. No doubt this policy also includes the intent that nuclear technology should be developed toward achieving a goal of economically competitive production of energy.

The federal government began to be committed toward carrying out the above policy, and established programs to this aim. The generation of electric power, which has appeared to offer the most promise, has been most actively pursued. Yet in the face of the various benefits offered by nuclear power, most of the groups who have opposed it have centered their objections on questions involving safety considerations. Those who are actively supporting the development of new plants within this industry have found themselves preoccupied with various safety matters in arguing their case with those who are opposing the industry.

The development of nuclear power safety philosophy will be discussed to show how it may have been influenced by and in turn may have influenced the growth of the civilian nuclear power industry. Some of the claims will be examined and analyzed for their validity in an attempt to find answers to such questions as: (1) What has been the acceptance of civilian nuclear power since 1954, and what future may be expected? (2) What factors influenced the development of a safety philosophy within the industry? (3) Is the current philosophy a good one -- or will it change? and (4) Have the safety regulations actually helped or hindered the growth of nuclear power and the rate of public acceptance?

Three case studies will be presented; these cases are believed to illustrate a good part of the controversy. The cases will include some discussion of claims and counterclaims, significant actions taken by the parties involved, and the final decision taken in each instance. Other significant material that is now available on this topic will be looked at, existing plans and policies will be analyzed, and evidence will be gathered to show the extent to which these are good, desirable, and should be continued.

The major thesis is that nuclear power safety philosophy has influenced the growth of the civilian nuclear power industry. The sections that follow shall concern themselves with:

(1) Establishing the validity of the above major thesis;

(2) Measuring the extent of such influence on the growth of the civilian nuclear power industry;

(3) Determining whether any positive action can be taken to offset observed influences that may be adverse to future industry growth.

B. Analytical Framework to be Followed

The following assumptions have been made:

(1) The economics of nuclear reactors, fuel cycle costs, and so on, are now or soon will be such that reactors as power sources will be economically advantageous compared to coal, gas, or

oil-fired power in many geographic areas;

(2) Nuclear power is destined to become an indispensable source of energy in the United States; the economic arguments in support of or against its development or use shall not be discussed here;

(3) Industry growth may be measured in terms of megawatt (MW) plant sizes in operation, planned output, changes in federal programs, and so on, as well as changes in total planned megawatt output of nuclear plants as a part of total output from all plants.

The following hypotheses and theoretical framework shall serve as a basis for evaluation of the problem that has been posed:

(1) A large part of the public concern with atomic power is in the area of safety, and arises from misunderstandings, false fears, and lack of communication.

(2) Certain industrial and organized groups have intentionally and successfully slowed the growth of a civilian nuclear power industry by interposing safety objections.

(3) Events and happenings related to the subject of 'atomic power safety' are frequently exaggerated and reported out of proportion to their true importance; genetic effects are overemphasized, and many people tend to be overly cautious.

(4) Certain industrial, scientific, governmental, and labor groups may be cited as 'proponents' or 'opponents' of the industry, and moves taken or planned by one group to extend influence or bring about change may be observed to bring also a reaction or countermove from another group.

(5) Certain steps taken by the federal government have had both detrimental or deterring effects as well as stimulating effects on industry growth.

(6) Positive action that could be taken to assist the advance of the industry could include, among other factors, programs of public understanding and successful power demonstration of specific types of nuclear reactors.

C. Importance of the Study

Atomic power safety is a complex topic with many areas that are not black or white. It requires special guidance and understanding and does not provide quick and easy answers to the layman looking for very precise statements on safety. The question of safety philosophy is a very controversial one, with divergent views involved, and provides a sound basis for worthwhile study. The costly delay that is claimed for unduly restrictive safety considerations is wasteful, and should be avoided. In the sections that follow, specific research and analysis will be performed in appropriate areas of this industry, including the specific area of safety, and evidence will be presented, discussed, and evaluated in support of the above hypotheses.

The evidence gathered and presented, together with the resulting narrative discussion and conclusions, will hopefully establish the above major thesis as valid within the conceptual framework indicated above. There is a dearth of statistical or tabular data on this subject since it deals with an infant industry with a good but very short record. There is no compilation of the number of complaints made or the approximate number of hours wasted because of intervenors or cranks or narrow-interest groups who are leading from conclusions when they resist with their loud protests.

Nor does there exist anywhere a definitive accumulation of the effort spent by regulating authorities trying to obtain answers to the questions raised within their prescribed set of groundrules for regulating and controlling.

Part of the evidence presented here shall include discussion of a selected chronology of actual cases bearing on the above hypotheses and shall illustrate the actions taken in each specific instance. Three cases illustrate significant actions taken in the recent past and will be presented as a means of adding more realism to this thesis.

The case studies to be presented shall include the following:

(1) Enrico Fermi Plant (Power Reactor Development Company) - Michigan.

(2) Ravenswood Plant (Consolidated Edison Company) - New York.

(3) Bodega Bay Plant (Pacific Gas & Electric Company) - California.

* * *

II. BACKGROUND AND EXPERIENCE RECORD OF THE INDUSTRY

A. Background of the Industry

In January, 1939, Enrico Fermi guessed correctly that neutrons might be given off during the fission process. He discussed this possibility with others who also realized the implications of a chain reaction, and several experiments were undertaken. During this same period, Dr. Albert Einstein first wrote to President Roosevelt to advise him of the great power potential from the splitting of the atom. The subsequent charter of the Manhattan Engineering District (MED) and the successful firing of an atomic bomb on July 16, 1945 are well known.

Fermi first successfully produced a self-sustaining chain reaction in a uranium-graphite pile, called "Chicago Pile -1" (CP-1), in November, 1942. The fact that subsequent work was carried on at Oak Ridge and Los Alamos is also known and will not be discussed here. However, as Dr. Glen Wensch, Chief of the Liquid Metal Cooled Reactors Branch, U.S.A.E.C., has pointed out in his introduction to the handbook of "Fast Reactor Technology -- Plant Design", the war effort forced aside any ideas of building reactors for civilian use. "... However, much of the work during the war years was directly applicable to and, indeed, necessary to the peaceful uses of nuclear energy."[1] Dr. Wensch also observes the interest of Los Alamos physicists in 1945, when they sought to build a plutonium-fueled, mercury-cooled fast reactor. Beginning in 1946, the reactor named

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[1] Glen W. Wensch, Fast Reactor Technology - Plant Design, Chapter 1, (Boston: Massachusetts Institute of Technology Press, 1965), p. 1-6.

"Clementine" was used as a critical assembly and provided much data until dismantled in 1953. "Experimental Breeder Reactor - I"(EBR-I) reached criticality in 1951 and served to provide still more data on reactor performance.

No standard design came from these efforts, however, and during the early 1950's the interest shown by industry was only minor compared with the potential, and the federal government moved to take positive steps to assist a more active development of peaceful uses of atomic energy.

1. Enabling Legislation

The Atomic Energy Act of 1946 established the United States Atomic Energy Commission (USAEC) as of January 1, 1947, to assume civilian responsibility from the Army's Manhattan Engineering District. After successful development and detonation of a hydrogen bomb in November, 1952, attention was concentrated more toward peaceful pursuits, and the Atomic Energy Act of 1954 contained the mechanism for a Power Reactor Demonstration Program and the stated objective of integrating nuclear power into the electric power economy.

Beginning in 1955, invitations were made to industry to submit their proposals to construct and operate nuclear power plants under the program. The response to the first round offer was relatively small, and a second round offer subsequently contained more liberal assistance provisions, such as waivers of fuel use charges and ownership of plant by the Atomic Energy Commission. A third round offer was also made later. In all, several proposals were received and accepted, and a few were rejected. Appendix A provides a statistical summary of operating and planned reactors.

2. Progress Since 1954

Since the passage of the revision to the Act, the following has taken place:

a. Two million kilowatts of nuclear power capacity have been put in operation, and another two and one-half million kilowatts are being planned;

b. Current United States generating capacity is about two-hundred million kilowatts;

c. Total capital investment for nuclear power facilities by the utility group is nearly one billion dollars;

d. The purchase of power plants is now possible on a fixed-price basis with guarantees of performance by manufacturers.[2]

Appendix B provides a list of large central station and prototype power plants that are operable, being built, or planned for the United States.

If one merely looks at the progress in terms of total kilowatts of capacity the progress in the past ten years appears to have been good. However, analysis of the status of plans for those reactor plants in the planning stages and the unfortunate preoccupation with safety considerations and the resulting cancellation of several important plants suggests that the situation could be better. Examination of the basis of complaints that have been made, including some study of their relative merit compared to their relative impact, will show the true nature of progress made.

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[2] Atomic Industrial Forum, Background Information on Atomic Power Safety, (New York: Atomic Industrial Forum, 1964) p. 8.

3. Importance of Nuclear Power

The major reasons for developing nuclear power are its promised lower costs and the fact that it is destined to become an indispensable power resource. There are other incidental benefits, also. These are the basic assumptions in preparing this paper, and there will not be a discussion of economic arguments in support of or against nuclear power development or use. Nuclear power is already competitive in certain high-cost fuel areas such as New England and west coast areas where the costs of fuel alone account for almost one-half the total costs to generate power. According to a recent estimate one-half the total power output in this country by the year 2000 will be by nuclear power.[3]

Another point that should be made concerning this new power is that its use for civilian electric power will aid greatly in conserving the existing limited fossil fuels for the uses for which they are particularly well suited. In addition, the heat equivalent of nuclear reserves in the United States is significantly greater than fossil-fuel reserves, as shown in the table below.

Table 1

ESTIMATES OF ECONOMICALLY RECOVERABLE FUELS IN THE UNITED STATES

Fuel	Units	Proven	Ultimate	Heat Equivalent of full Reserve
Coal	Billion Short Tons	20	830	20Q
Petroleum	Billion Barrels	40	400	2Q
Natural Gas	Trillion Cubic Feet	260	1250	1Q
Uranium	Thousand Short Tons	240	5000	300Q

Source: Division of Technical Information, Power Reactors, U. S. Atomic Energy Commission, (Oak Ridge, 1963) p. 2.

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[3] Civilian Nuclear Power... A Report to the President - 1962, U. S. Atomic Energy Commission, (Washington, D. C. 1962) p. 11.

The term usually used for heat equivalent is "Q", and refers to the equivalent of one quintrillion British Thermal Units. As shown by Table 1, the uranium reserves exceed the combined reserves of all other fuels by a factor of approximately 15.

B. Experience Record of the Industry

As noted above, two million kilowatts of electric power capacity are in operation or an advanced state of construction. Appendix B provides a list of these reactors.

Insofar as the safety record of the industry is concerned, there has never been a reactor accident involving loss of life or danger to the public at any of these commercial plants. The record is very good but it is also very short. Perhaps the single most important reason that the nuclear power industry's safety record is superior to all other industry is that safety considerations have been made a prime requisite for all new reactor designs. In addition, the Atomic Energy Commission has imposed a complex group of controls, regulations, procedures, and inspections that have all but eliminated even the slightest chance for a serious accident.

In addition, the radiation exposure limits allowed for the public in connection with nuclear power plant operations is only a small fraction of the level allowed by radiation protection standards. This allowance is typical of the conservative approach to safety shown throughout industry and the regulatory groups. There has never occurred an instance of any violation of the Atomic Energy Commission's radiation protection standards by any nuclear power plant.[4]

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[4]John F. Hogerton, Background Information on Atomic Power Safety, (New York: Atomic Industrial Forum, 1964) p. 33.

1. Summary of Reactor Accidents

Although there has never occurred a serious accident in the operation of any existing nuclear power plant, there have been criticality accidents in experimental and prototype reactors, and these are briefly summarized in Appendix C.

One of the valuable results from reactor accident experience is that subsequent design criteria can incorporate the necessary preventive means to keep similar accidents from occurring in the future. As shown in the appendix, where an injury has resulted in death to someone, the accident has occurred in an experimental reactor or weapons research facility. However, an interesting observation that has gone without notice by many occurred during the "SL-1" accident on January 3, 1961, as shown in Appendix C. Although severe pressures and high radioactivity levels had occurred, the radiation did not extend a hazard level outside the reactor building; and the SL-1 experimental reactor was not within a containment shell!

2. Waste Management

Radioactive waste is defined as:

> "Equipment and materials (from nuclear operations) which are radioactive and for which there is no further use. Wastes are generally referred to as high-level (having radioactivity concentrations of hundreds to thousands of curies per gallon or cubic foot), low-level (in the range of 1 microcurie per gallon or cubic foot), and intermediate (between these extremes).[5]

Since the very early days the Atomic Energy Commission recognized a need for carefully controlled programs of waste management. Yet the exaggerations

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[5] U. S. Atomic Energy Commission, Nuclear Terms - A Brief Glossary, Division of Technical Information (Washington, D. C. 1964) p. 34

made about nuclear activities in connection with pollution of streams and the atmosphere with deadly or harmful radioactive wastes have been many. Claims have been exaggerated, and undoubtedly have resulted in quite a total misunderstanding of the effectiveness of waste management.

In considering this subject of waste, one must recognize the existence of high-level as well as low-level wastes, as shown in the definition. A reactor plant's purification system consists of filters, evaporators, monitors, counters, demineralizers, and so on, all designed to control waste concentrates well within the permissible standards. Both types of waste are stored temporarily, and where the type of waste is such that it cannot be reduced below a stated level, it is packaged in approved containers for shipment to a burial site. Waste of the low-level variety is able to be discharged in very small quantities from the plant. This waste is always within the allowable levels conservatively set by Atomic Energy Commission regulations, and is subject to monitoring on a routine basis to assure that standards are maintained.[6]

The concepts of air pollution and stream pollution are important to public health and safety, and will be discussed further below:

a. Air pollution - is a matter of concern, especially to those who live nearby an atomic plant. For this reason there have been established certain permissible levels for 'radioactive' gases that may be released into the atmosphere from a reactor plant. These levels are based on the assurance of dilution of low-level waste gases in the atmosphere, and the annual limits that may not be exceeded

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[6] John F. Hogerton, op. cit., p. 10.

are set so low as to be harmless even to those persons who live all year at the edge of the plant site. As a matter of truth, there simply is no pollution of the air from 'radioactive' gases discharged from power plants.

b. Stream pollution is another popular myth associated with nuclear power. Some of the loudest objections to the LaCrosse (Wisconsin) Boiling Water Reactor (LACBWR) came from nearby fishermen who were needlessly concerned about their fishing area along the plant site at the Mississippi River. Again, federal standards require that the treated low-level wastes that are allowed to be discharged into any river at any reactor plant must meet the standards for drinking water. The discharged water is, in fact, only mildly radioactive, and is diluted further as it is washed downstream. Strict controls are maintained on this, also, and there is, in fact, no stream pollution.

3. Comparison With Other Industries

There is no difference between the electricity produced through nuclear power and that produced by conventional means, but the off-products are as different as black and white. Yet the need to deal with noxious waste products is clearly not unique to atomic energy installations; several other industries must also deal with this problem daily. The disposal of radioactive wastes, however, does represent a situation of relatively little historic experience with which to guide the present. The relatively short life and experience with this industry doubtlessly has much to do with the present state of its acceptance.

A comparison of the nuclear power industry with other industries, including the 'conventional' power industry suggests that the harsh criticisms heard against nuclear power really have been a flip-flop of the awful truth. The by-produuts given off from the burning of coal and other fossil fuels include such noxious matter as carbon monoxide, sulfur dioxide, nitric oxide, and the cancer-causing carcinogens.

In September, 1963, United States Senate hearings looked in detail at the subject of air pollution.[7] Some of the more important points covered at these hearings included:

- Discussion of the pollution incident at Donora, Pennsylvania, in 1948, in which 5,000 people were made ill and 17 died from the effects;

- Reference to severe pollution conditions in London in December, 1952, when certain adverse meteorological conditions caused the death of 4,000 people! Similar conditions in 1962 killed another 750 people, even though certain precautions were taken earlier;

- Discussion of a high concentration of sulfur dioxide in New York City during 1953, when the 'unusual' meteorological conditions (based on statistical computation covering the next nine years) brought on the deaths of 200 people attributed to this single event.

In addition to the above calamity situations of a sudden nature, there is now accumulating more evidence that continued, repetitive exposure to 'generally acceptable' pollution levels over long periods of time can

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[7] Hearings Before A Special Subcommittee on Air and Water Pollution of the Committee on Public Works, U. S. Senate, 88th Congress, First Session, (Washington, D. C., U. S. Government Printing Office, 1963) pp. 73-84.

aggravate as well as contribute to respiratory ailments, and even lung cancer.[8]

In a recent article,[9] Dr. Chauncey Starr, President, Atomics International Division of North American Aviation, has observed that the nuclear power industry's technological approach has been the most conservative in all engineering history. Whereas past custom has always been to proceed first with applications and to consider safety less important, the same is not true for nuclear power technology. With past applications the developers later on "...await an empirical balance between safety constraints and social value." The automobile and the airplane both illustrate this, as pointed out by Dr. Starr, and currently, he observes further, any child can go into any supermarket in almost any town and buy enough insecticide to kill his entire family.

The practical difference between the radioactivity from a reactor and the poisons, irritants, and carcinogens given off from burning coal and oil is, on one hand, "...the acute awareness of the public of the controlled but potential health hazards associated with radioactivity and, on the other hand, an unawareness and apathy concerning the existing public health hazard arising from the use of coal and oil."[10]

The spending for air pollution control by U. S. industry would be quite staggering. Consolidated Edison alone has invested more than $100 million in the past thirty years for such controls.[11]

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[8] Hearings Before A Special Subcommittee on Air and Water Pollution of the Committee on Public Works, op. cit., p. 73-84. [11] Ibid., p. 372.

[9] Dr. Chauncey Starr, Radiation In Perspective,"Nuclear Safety", Summer 1964, p. 326. [10] Ibid., p. 327.

With all the effort underway to control air pollution there shall still continue to be disasters when the proper inversion conditions occur; and there shall also continue the gloomy prospects of respiratory ailments, disabilities, physical discomforts, and a few other unspecified items. As Dr. Starr has pointed out, "The death rate is only the statistically visible part of the iceberg of air-pollution effects."[12]

Mr. Hardin Jones of the Health Physics Society makes a comparison of industrial hazards in easily understandable terms when he estimates that the individual who lives his entire life next door to an operating nuclear plant would have his longevity statistically reduced by a fraction of a day, or about the same effect that would occur after smoking about two packages of cigarettes during a lifetime.[13]

A further comparison can be easily understood also: A man standing on the outside of a run-of-the-mill containment shell of an operating nuclear plant would receive more radiation from the radium dial of his wrist watch than from the reactor operation.

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[12] Dr. Chauncey Starr, op. cit., p. 328.

[13] Hardin Jones, Estimation of Effect of Radiation Upon Human Health and Life Span, Health Physics Society Meeting, June 1956.

III. DEVELOPMENT OF A SAFETY PHILOSOPHY

A. Influence of The Bomb After World War II

Experience during and after World War II with the atomic and hydrogen bombs left an intended cloak of secrecy around atomic fission and fusion. The singularly outstanding aspect that was very well known and understood about the new weaponry was its devastating effect and the havoc and damage that could be caused by a device that came in a mighty small package. Any mention of the Japanese cities of Nagasaki or Hiroshima would at once cause most to recall vivid scenes of destruction from blast and thermal effects. These have been easily confused with radiation effects; and the public has a long memory.

Dr. Theos J. Thompson, Director of the Nuclear Research Center at the Massachusetts Institute of Technology, has observed that the public worry and apprehension about nuclear power reactors stems mainly from the public memory of the destructive nature of atomic power during the last war. The unfortunate circumstances are that man's first experience with the nuclear potential was in the ugly form of a bomb. Dr. Thompson observes further: "If gasoline had first been introduced in the form of jellied gasoline bombs spreading havoc and destruction in war... the development of the automobile would have been delayed for many years. The talk would have been of exploding gasoline tanks at every corner, of children being burned to death and of other, disastrous fires as a result of using gasoline-powered cars."[1]

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[1] Dr. Theos J. Thompson, How Safe is a Nuclear Reactor?, U. S. Atomic Energy Commission, (Washington, D. C., Division of Technical Information, January, 1964)

Fears about nuclear power, therefore, are natural fears, but unfounded for the most part. The plain fact is that a nuclear reactor cannot explode as a bomb. There are such fundamental differences of interior design and mechanism that such an occurrence would be totally impossible. Further, the fuel requirements of a bomb call for high-purity fissionable material; a reactor needs to use an alloy or other chemical compound that simply won't work in a bomb. If all the world's scientists took all the world's nuclear reactor fuel and arranged it in any manner they wanted they could not make a bomb bigger than a small firecracker, according to Francis L. Brannigan, a safety engineer for the Atomic Energy Commission.[2]

Yet people tend to be overly cautious when involved in a new area, particularly if they think it has any danger involved. A large part of the public's concern with atomic energy has grown out of the publicity given to genetic effects, especially dating from Hiroshima. The concept of defective children from radiation exposure became quite common, and statistical theories and exaggerations led to still more fears and misconceptions.

One of these misconceptions is that all radiation is bad, when the truth is happily that more and more benefits are being discovered through current research. A few people interpret 'sterility' to mean 'virility' and thereby contribute to further confusion. The nature of many non-specific hazards has thus in time become an elusive area. As further observed by Mr. Brannigan, many attitudes and beliefs formed during the recent past now make up the base from which public officials, business executives, and others start in considering the nuclear power program. And factors such as these form the

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[2]Francis L. Brannigan, "I Don't Like Atomic Energy Because..." Speech before the American Nuclear Society, (Hinsdale, Illinois: 1964).

frame of reference within which nuclear reactor safety philosophy has been developed. And while the great body of safety philosophy is designed to prevent or eliminate undue hazards and accidents and allay anxieties, it can at the same time create a host of new fears merely by discussing the type of catastrophes and events it contemplates.

Probably as a result of all the attention given to the development of a superior set of safety regulations, the atomic energy industry is safest of all industries, as discussed in Chapter II. In most industries or activities of man such as building load limits, speed limits, and so on, a safe ratio of 3 to 1 is normally acceptable. But in the case of radiation it is 80,000 to 1! Obviously nobody can get hurt at the low limits set by the rules for radiation. Yet one could easily imagine that a panic could be started if one were to yell that a radiation accident of 1000X had just occurred.[3]

There is an important philosophical difference between the nuclear and the other industries: The applicant in the atomic energy industry has the burden of proof of safety placed on him. In all other industries just the opposite is true. Customarily there exists a faith in most regulatory systems; for example, we depend upon those who are responsible to put the chlorine and fluorine in the water.

All the safety rules the world has today can usually be traced back to some accident that has occurred in the past. The Iroquois fire in Chicago, for example, showed a need to have doors open outward. In the atomic energy industry, however, the regulations tend to refer to nuclear materials as explosives, and shipping labels at one time showed a bomb on them.[4]

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[3]Francis L. Brannigan, op. cit., p. 5.

[4]Ibid., p. 3.

Since the early days, however, many refinements have taken place in the beliefs and attitudes surrounding this subject. The stigma resulting from the bomb has faded at least a little bit as newer concepts involving this new power have come into the foreground.

B. New Concepts

With the birth of a new industry many new concepts should be expected to come into existence. "The radioactivity due to the fission products in the 'spent' uranium slugs from a nuclear reactor, for example, is many times greater than that due to all the radium -- about two and one-half pounds -- extracted in nearly sixty years. The problem of radiation protection has thus become one of considerable importance."[5]

Starting with the axiom that 'radiation that doesn't hit anybody does not hurt anybody' the nuclear industry has been faced with some new and interesting situations to be anticipated, evaluated, and controlled. Some of these are discussed in the sections that follow.

1. Criticality

Enrico Fermi first achieved nuclear criticality in 1942 at Chicago, and the bringing together of the proper ingredients sufficient to make up a critical mass was the basis for proceeding with bomb development. However, the criticality necessary to make a bomb and the controlled criticality necessary to operate a reactor are very much alike yet very much different, also. In a nuclear reactor there must occur just the proper amount of

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[5] Samuel Glasstone, Sourcebook on Atomic Energy, (Van Nostrand Company, Princeton, New Jersey, 1958) p. 589

controlled criticality to achieve and maintain the heat-producing fission so that steam-driven turbines can be operated without generating high temperatures and pressures so that damage occurs. One can become as absolutely dead from radiation from a bomb exploded miles away as from a reactor several feet away if precautions are not taken. Criticality is therefore dangerous by definition. If a reactor core is allowed to become accidentally critical, or if its fuel is allowed to be stored or transported in an unsafe geometry condition, there could be harmful radiation to those nearby.

And so just as man had learned to comprehend 'criticality' in the bomb sense he was asked to accept it in another way. But the more impressive memory of the concept of criticality was that it was something to stay several miles away from. The possibility of achieving criticality in a safe, controlled condition was very difficult for anyone other than a reactor physicist or engineer to understand or accept.

2. Accident Prevention -- Safeguards

The safety of people has been established as an overriding consideration. In a power reactor there are certain natural safeguards as well as those that can be designed into the system. Among the natural safeguards that exist are the fact that a rise in fuel temperature slows down the fission rate, decreases fuel density, and in fact lowers reactivity. On this basis, natural safeguards tend to be self-correcting. In addition, a designer must build in certain design safeguards, also. And every system designed for a nuclear power plant must be reviewed from the standpoint of how it might affect public safety.

Dr. Glen Wensch has observed that certain design criteria seem to be evolving, as follows: "(1) The given system should be designed for maximum normal operating conditions and for all credible maloperations, (2) Simple failure of a given system to perform its basic function should not create a safety problem directly or give rise to safety problems in other systems, (3) For each system normally containing radioactive mat^rial, the effects of an uncontrolled release of this material should be analyzed and, based on the degree of hazard involved, measures taken to prevent such a release or to control it should one occur, and (4) Systems connected to or passing through the reactor building should not compromise the containment aspects of the building."[6]

From the beginning reactor safeguards have been carefully instituted and revised as needed and allowed within the above framework. The Atomic Energy Commission has a statutory Advisory Committee on Reactor Safeguards (ACRS) made up of a group of independent experts who meet and function independent of the AEC. The ACRS reviews applications from power plant operators, holds hearings, and makes public its findings. An applicant must describe the design of his plant, summarize the hazards in a report, and show all of the safeguards he intends to provide. Here again the unique nature of the new industry reveals itself, since the applicant has the burden of establishing the adequacy of his safeguards. The result is simple: If he cannot convince the reviewers, represented by some of the most knowledgeable experts in the land, he does not receive approval to proceed.

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[6] Dr. Glen W. Wensch, op. cit., p. 1-31.

3. "Scrams"

This term is among the new and interesting vernacular born with the industry, and is defined as:

> "The sudden shutdown of a nuclear reactor, usually by rapid insertion of the safety rods. Emergencies or deviations from normal reactor operation cause the reactor operator or automatic control equipment to scram the reactor."[7]

There are a number of operating conditions that might call for a sudden control rod activation mechanism to shut down a reactor. Many of these are highly improbable, but must be provided for. The scram mechanism can function automatically during a given set of conditions, even unnoticed by a highly skilled reactor operator. Control rod drives, for example, involve lifting of control rods by electrically-driven motors. Any power failure drops the rods by gravity, and 'scrams' the reactor.

This term, like some others, is occasionally misunderstood. If someone near a reactor plant were to hear that a scram had just occurred at the plant he might conceivably think that everyone had suddenly abandoned the building for obvious dangerous reasons. Such would not be the case.

4. Reactor Excursions

This term also found its way into nuclear power vernacular and has been misunderstood by some. It is defined as:

> "A sudden, very rapid rise in the power level of a reactor caused by supercriticality. Excursions are usually quickly suppressed by the reactor's negative temperature coefficient and/or by control rods."[8]

As a descriptive term, the word refers to a deviation by the reactor from its proper course. By no means does it refer to a traversed distance

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[7] Nuclear Terms - A Brief Glossary, op. cit., p. 3.

[8] Ibid., p. 11.

or any outward physical movement of reactor internals. Yet there must be those, too, who have heard of a reactor going on an excursion and have imagined that it was taking a short trip someplace!

Fortunately such misunderstandings can be cleared up quickly for those interested in clearing them up. But once confusion is started it is hard to stifle. People often prefer to go on believing what they only suspect to be the truth than listen to actual, dull facts.

Such misconceptions are not offered as a major problem. But they do show part of the larger problem of a tendency to create and extend confusion and misunderstanding surrounding this program.

5. Containment

This term refers to:

> "The provision of a gastight shell or other enclosure around a reactor to confine fission products that otherwise would be released to the atmosphere as a result of a major accident."[9]

This concept probably also worries the average man who probably wonders what there is about reactors that is so mysterious and dangerous that it must be contained.

The familiar containment shell on a nuclear plant is there as the last barrier to keep any accidental release of radioactivity from reaching the surrounding environment. Reactor designers must postulate a 'maximum credible accident' which assumes, however unlikely, that a great many possible but improbable events occur at the same time. The unhappy combination is supposed to represent the worst situation that could happen.

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[9] Nuclear Terms - A Brief Glossary, op. cit., p.6.

Based on such conditions happening, certain maximum pressures and temperatures would be created and radioactive substances released from the reactor. The designer must create a structure capable of holding back pressures far beyond those postulated, so that a leak-tight building is maintained.

Recent designs for containment shells are becoming more and more complex to assure safety. One recent development includes the concept of multiple containment, or the addition of a second shell around the inner shell, in case of leakage in the inner shell from an accident. This latest method has been criticized as layering on even more conservatism on a system already conservative. "Whereas the use of a single container implies lack of confidence in the safety of the nuclear system and its safety features, the use of multiple containment implies lack of confidence in both the nuclear system and the single container. The next step obviously is triple containment."[10] The Ravenswood reactor was proposed to have a double containment shell.

On the basis that leakage cannot occur through a containment shell there is actually no reason why a reactor plant could not be located within a populated area, near utility load centers.

6. Plant Siting Criteria

With the advance of reactor technology and the desire to build plants a need for definitive site criteria became more apparent. The original site criteria was set most conservatively and has not budged since that time.

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[10] Nucleonics Week, (New York, McGraw Hill, November 7, 1963) p. 3.

Reactor siting requires careful consideration of many factors, including dimensions and characteristics of the site, population density near the area, the use of the area such as for farming, industry, or residences, and such other factors as the seismology, meteorology, geology, and hydrology of the site.[11] Failure to come within the published limits set for any of the above could and often does result in a rejection of an application.

To avoid head-on collisions with siting criteria, plants to date have been built in relatively isolated, sparsely populated areas. Unfortunately, from a cost standpoint, the plants are far from their load centers and such locations have increased the delivery cost of electric power from these plants.

As will be shown in Chapter VI on the case studies on Ravenswood and Bodega Bay, where a reactor builder tried to vary the above pattern and build his plant near a load center the opposition defeated the move. The fact that, in such cases, the proposed plant was already funded with the construction and other arrangements well along the way has made the defeat even more costly. There is rarely a case of zero opposition on a proposed site; however, as shown later, Consolidated Edison's construction of Indian Point Atomic Power Facility was almost the only example of public acceptance with practically no outcries from any sector. This probably happened because the plant was announced in 1954, the year the Act was passed, and while most of the opposition was asleep. In due course, however, the opposing forces became alert to the impact of nuclear power and began to make themselves actively heard.

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[11] U. S. Atomic Energy Commission, Public Safety Programs in Atomic Energy, Division of Technical Information (Washington, D. C., Government Printing Office, April 1964). p. 10.

7. Radiation Protection Standards

Many misconceptions have occurred in conn^ction with radiation and the possibility of ill-effects from it. Many will recall the radium dial cases of forty years ago, and the attention they drew to radiation hazards. The cases were verywell known but exaggerated. Further, the early fears from 'thalidomide' in England were based on radiation involving a nuclear reactor nearby, and created several false fears before the real culprit was named.[12]

The "Hiroshima Maidens" today are still actively on tour showing their tragic disfigurements from the war. Probably very few who see them are consciously aware that blast and thermal effects caused what they see. Any other war-time bombing could and probably did cause worse to happen, but Hiroshima is of special interest, and no doubt many viewers come away after seeing these girls with some dreadful opinions about the harmful effects of 'radiation' on people.

Aside from some of the confusion resulting from events such as those discussed above, there was a true need to define safe practices and to establish adequate procedures for handling radioactive materials. On an international level, there are several committees and agencies performing this function. The Atomic Energy Commission is the agency in this country that determines safe procedures and practices, and sets the standards. The USAEC is assisted by the Federal Radiation Council, which has a membership including the Secretaries of Health, Education, and Welfare, Defense, Commerce, and Agriculture. There are also other advisory committees providing expert input into the setting of radiation standards.

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[12] Francis L. Brannigan, op. cit., p. 2.

The Federal Radiation Council recommends allowable radiation limits to the AEC for areas near nuclear plants, and the AEC, following a conservative practice on this subject, permits only a small percentage of the limits suggested by the Council, and these lower limits are then published in the Code of Federal Regulations as law. One should therefore be aware that much of the opposition and argument against 'living next door to the atom' takes place within the deliberately narrowed confines of this fairly short part of the total spectrum.

In time a formula for atomic power safety has evolved as basic guides for the industry:

> "1. In designing an atomic power plant, evaluate the possible types and degrees of accidents;
>
> "2. By taking advantage of natural laws, by providing engineering safeguards, by conservative design, and by careful construction and operation, do all that can be done to prevent these accidents from occurring;
>
> "3. Build into the plant dependable means of containing the consequences of accidents should they occur;
>
> "4. Check and double check the safety of the design, construction, and operation of the plant through licensing and compliance procedures;
>
> "5. Conduct supporting safety research and test programs."[13]

In developing radiation protection standards AEC has identified maximum permissible concentration philosophy, defined as:

> "That amount of radioactive material in air, water, and foodstuffs which competent authority has established as the maximum that would not create undue risk to human health."[14]

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[13] John F. Hogerton, op. cit., p. 13.

[14] Nuclear Terms - A Brief Glossary, op. cit., p. 18.

The maximum levels are set very conservatively, and for many areas near nuclear plants often resemble the natural background level. They are set so as to provide the maximum protection to the population consistent with the formula for safety described above. Even though established by qualified authority using the best technical advice available, the standards are not understood by the average citizen. He simply does not understand the levels or the basis for determining them. But then the radiation he might receive from his television set or his watch dial is a mystery to him, also. He may obtain a chest or dental X-ray every year or so, but if he were to receive one every day or every few hours there would occur a point at which some calculable harm would occur. Within such extremes of exposure there is a range of 'safety' for him.

8. Hazards Summary Reports

This report must be compiled by an applicant for a reactor license and presented to AEC's Division of Reactor Licensing. A Hazards Summary Report must describe the type of reactor being proposed and must indicate design criteria and assumptions made insofar as the full range of hazards that might be contemplated for the plant. The report must include description of the maximum credible accident that could occur assuming all of the wrong conditions, control failures, coolant loss, and everything else all gets out of whack at the same time. On this basis, the maximum credible accident becomes an incredible accident, but is interesting to postulate since it points ultimately toward an upper limit beyond which nothing can happen.[15]

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[15] John F. Hogerton, *op. cit.*, pp. 18-21.

The Hazards Summary Report is reviewed by the AEC and the ACRS, and is made public as part of the total license application package. It forms a part of the record for all to see, including those who may oppose the project.

Just as the conservative, reduced radiation limits serve as a target for argument by some opponents of nuclear power, so do the levels of radiation and types of accidents possible from a 'maximum credible accident' get tossed around as a believable norm or likely result. A small part of the truth can be twisted out of proportion to its true meaning. Some of the conditions and events dreamed up in Hazards Summary Reports are about as likely to occur as the Statue of Liberty is likely to take a swan dive into New York harbor!

During the days of the aircraft nuclear propulsion program, someone predicted that the maximum credible accident could occur if a nuclear powered aircraft were to crash into the N. S. Savannah while anchored in New York and the whole works would then sink on top of the Nautilus below! This was done, of course, with tongue-in-cheek, but it points up some of the similar assumptions made by those who build safeguards into reactors and must prepare summary reports about the possible hazards that might occur.

9. Nuclear Hazards Indemnity - Price Anderson

Consideration of the possible financial liability possible from a reactor accident resulted in passage in 1958 of the Price-Anderson Federal Nuclear Indemnity Act. The Act was designed to protect the public from any loss and damage that might result from nuclear accidents, but primarily was passed as an encouragement to utility firms to build nuclear power plants. The Act calls for $60 million of required private coverage and up to $500 million of federal indemnity for reactors of 100 Megawatt electrical (MWe) or more. Without Price-Anderson the utilities could not afford to move into nuclear power, since the possibility of unlimited claims against them from a nuclear accident would be prohibitive.

The coal interests strongly oppose this Act on the grounds that it puts the fossil-fuel interests at competitive disadvantage. The coal lobby regularly leads a vigorous attack whenever Price-Anderson comes up for debate. The existence of Price-Anderson and the federal government's third party liability coverage is interpreted by many who speak against nuclear power as an admission that nuclear power plants are a major safety hazard. These discussions assume in error that the very large amounts are indicative of the likely extent of suffering and damage to be expected. As pointed out by a knowledgeable spokesman on this topic: "We must make it more clear that in the event of a reactor accident, the vast bulk of the potential physical suffering and personal injury can be avoided by evacuation and that the liability or indemnity problem would be more likely one of indemnifying people for the loss of the use of their property (which was necessary to keep them safe) rather than with indemnity for disease and suffering. The fact that, should such a fallout incident occur despite all precautions, an exchange can be made of personal injury for dollars, by evacuation, is often not made clear."[16]

All of the above new concepts, need for safeguards, protection standards, siting criteria, radiation hazards, and so on, have formed the basis within

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[16] Francis L. Brannigan, op. cit., p. 4.

which a safety philosophy has developed for this industry. Nuclear power is a highly regulated and controlled industry for the foregoing reasons, and conducts most of its operations in a fishbowl atmosphere. Safety philosophy has been developed with the industry, and has not changed with it. Safety philosophy deliberately has been set on a conservative plane, perhaps to be relaxed some at a future, as yet unspecified, date.

Although this paper does not concern itself with the economic arguments for nuclear power, one point should be made in this vein concerning the pertinent safety philosophy involved. According to one very reliable source the added costs of preparing hazard summary reports, safety design specifications, traveling to and from safety hearings, and otherwise meeting the safety requirements before obtaining license approval to construct or operate a plant amount to an average of one to one and one-half million dollars additional cost for each nuclear power plant.

* * *

IV. LICENSING AND REGULATING NUCLEAR POWER

A. General Considerations

The operation of complex and sophisticated reactors involve the creation of higher pressures and temperatures than ever generated before. Within this framework a high degree of safeguards must be and in fact are being engineered into nuclear plants. As a means of controlling these activities and protecting public health and safety, the law provides that no person may construct or operate a nuclear power plant without first obtaining a license from the USAEC. Although superior engineering talent is applied to this activity, there always exists a possibility of human error, and for this reason the AEC has developed an elaborate system of checks and balances, including some very stringent safety procedures, independent review by experts, and a policy that assures a well-informed public on each plant application.

B. USAEC Organization

The Atomic Energy Commission is an independent federal agency, and is headed by a 5-man commission appointed by the President. Its authority to license and regulate nuclear power plants was contained in the 1954 Act. The AEC has the additional objective of fostering peaceful uses of atomic energy, including nuclear power. In addition, the AEC is responsible for the production of nuclear materials for national defense.

The promotion of nuclear power and the regulation and licensing of such power has created a dual role for the AEC. To avoid conflict in this role, the Commission has established a separate regulating staff. In 1964 this staff was expanded to include four new divisions: Reactor Licensing, Materials Licensing, Safety Standards, and State & Licensee Relations. The Division of Compliance functions separately to these four groups by conducting frequent inspections of a licensed plant during construction.

By statute there also exists the Advisory Committee on Reactor Safeguards (ACRS). This group consists of several independent experts representing many large firms in the chemical, petroleum, explosive, and insurance industries, as well as several universities and the weather bureau. The ACRS receives applications after they have been reviewed by AEC, makes further detailed study, and holds conferences with the applicant. ACRS findings are made public.

An Atomic Safety and Licensing Board is also appointed by AEC. This board receives applications after they have passed through ACRS and AEC, and then arranges to conduct public hearings at or near the proposed site, where state and local officials and the public are invited to testify on the proposed construction of the nuclear plant.

Insofar as site selection is concerned, the AEC looks at the basic hazards that might be involved in the plant in relation to population density, distances, safeguards, and such other factors as safety of design, maximum credible accident, exposure dose indices, reports prepared on the area, design studies, test results, and past experience.

AEC review concerns itself with fundamental design areas, including a detailed review to verify that the reactor possesses inherently safe, favorable characteristics, fail-safe controls such as assurance of shut-down in emergencies, and other adequate safety margins. Reviewers also look for redundancy of design that would provide backup. The burden of proving safety rests with the applicant in such cases.

C. Controls and Preventive Measures

In addition to the above reviews of site selection and plant design, the AEC looks thoroughly into construction practices, including design specifications, choice of materials, and construction techniques. Follow-up inspections and tests are conducted to assure that regulations are met.

Once an operating license is issued, the AEC assures that plant operating responsibilities have been spelled out, and that written procedures and formal instructions exist or a plant operating manual has been issued. Approved procedures contain internal checks and balances, also, and must be adhered to by plant staff. The operation is also reviewed from time to time to assure that limits are understood. Changes must be approved, and orderly maintenance schedules must be met. Good records must be kept. All reactor plant operators must be licensed, and require a training and an apprenticeship period. Post-operation surveillance is very systematic. From start to finish, there is a heavy emphasis on safety.[1]

In the case of those reactors that are AEC-owned and therefore do not require licensing, the AEC has voluntarily provided for public review of safety matters. This is called the principle of "parallel procedures" -- and it requires that appropriate reports prepared by the contractor, the ACRS, and AEC's Division of Reactor Licensing (DRL) all must be made public and hearings conducted. AEC thus places its own (second round) Power Reactor Demonstration Program reactors in the same fishbowl and subject to the same reviews as those plants requiring licensing.

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[1]Clifford K. Beck, speech before the Atomic Industrial Forum (New York: June 24, 1964)

1. Construction Permits

Outlined below is a summary of procedures followed in the issuance of a construction permit for a reactor plant.[2]

An applicant who plans to build a plant first discusses the suitability of the proposed site with DRL and ACRS. He thereby learns of the acceptability of the site and also gains an idea of the data he must provide in the application. He later files a preliminary safeguards report which gives detail on site data, technical aspects of the reactor, and discusses any accidents and how he proposes to prevent any overexposure to employees and the public. During the review of his application, the following normally takes place:

The Division of Reactor Licensing:

- Studies the applicant's Preliminary Safeguards Report
- Sends copies to ACRS, public officials, and AEC's Public Document room
- Makes public announcements concerning the reactor
- Publishes notices in the Federal Register
- Places copies of all filings and correspondence in the public record

The Advisory Committee on Reactor Safeguards:

- Considers DRL analysis and Preliminary Safeguards Report
- Meets with DRL and the applicant
- Reaches conclusions on safety of the proposed reactor
- Reports findings to AEC and makes it's report public

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[2] U. S. Atomic Energy Commission, Licensing of Power Reactors, Division of Technical Information, (Washington, D. C., U. S. Government Printing Office, 1963)

If DRL has reached a favorable conclusion and the ACRS report is also favorable, then:

The ACRS:

- Schedules a public hearing (in addition to the informal meetings that AEC may also hold)
- Furnishes copies of the ACRS analysis to all newspapers in the area near the reactor site.

The hearing is conducted either by a hearing examiner, or by an Atomic Licensing Board that:

- Receives the application, plus any amendments, and other documents into the record
- Hears testimony from the applicant, AEC regulatory staff, and from any intervenor, public official, or other person wanting to make a statement or 'limited appearance'.

The Atomic Safety and Licensing Board subsequently:

- Considers all evidence that is presented
- Issues a decision based on all of the above, for AEC review, or in the absence of such review, issues a decision to become effective as of a certain date.

If the decision authorizes it, a construction permit is issued. "The permit must include a finding, however, that AEC is satisfied that it has enough information to provide reasonable assurance that a facility of the type and size proposed can be constructed and operated safely at the proposed location."[3]

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[3] Licensing of Power Reactors, op. cit., p. 7.

Based on all of the foregoing, included with several repeated intermediate steps to assure that all questions raised along the way are adequately and carefully answered, reactor construction may proceed. Periodic inspections are performed by AEC's Division of Compliance to assure that all requirements are met.

2. Operating Licenses

Assuming that no serious problems develop and the intervenors do not have their way, the applicant submits his operating plans. These include emergency procedures, final reactor design details, nuclear core design, and plans for radioactive waste disposal.

The DRL:

- Reviews the application again, and
- Gives an analysis of it to ACRS, who makes all reports public.

After ACRS and DRL have completed their safety reviews, the AEC may issue an operating license, or it may elect to schedule further hearings to consider the license. If no hearing is scheduled, a public notice then allows 30 days for an intervenor to petition. Assuming no intervention then arises, the license is issued and the safety aspects are made public. But if a public hearing has to be held, the resulting decision from the hearing examiner or from the board must be reviewed by the AEC.[4]

Licenses may be provisional, such as in the case of the Enrico Fermi Fast Breeder Reactor at Lagoona Beach, Michigan, as discussed in Chapter VI. The Fermi plant was allowed to proceed to 1 megawatt of power after years of battling as far as the Supreme Court, who ruled the intervenor's case was without merit.

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[4] Licensing of Power Reactors, op. cit., p. 9.

3. Reporting Incidents

Maximum permissible concentrations are defined, as well as all operating procedures with which the reactor operator must live. Any accidents that bring about any property damage or personal injury must be reported at once, in accordance with licensing regulations, and any 'incidents' that could be construed to affect the safety of the plant must be reported and made public.

"Thus, reactors are subjected to detailed review by technical experts before construction is permitted, before operation is permitted and during the entire period of their operation. In the event an unsafe condition is discovered after operation begins, the Commission has the authority to order the licensee to shut down the reactor and take any safety measures which may be necessary. It should be emphasized, however, that the outstanding safety record of the atomic energy industry has been achieved because persons who deal with atomic energy respect the potential hazards and exercise great care in the handling and use of atomic materials."[5]

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[5] Licensing of Power Reactors, op. cit., p. 9.

V. INFLUENCE OF SPECIFIC INTERESTS -- HUMAN FACTORS

About four-fifths of the electricity used in the United States is from steam-electric power plants. Almost all of the energy needed to operate these plants comes from fossil fuel; atomic fuel is used to generate only a small fraction of the total.[1] A recent AEC estimate indicated that by the year 2000 the amount of electric power production from nuclear power would be equal to that produced by fossil fuel.[2] The implications of such a prediction naturally awoke some opposition.

A. Opponents of Nuclear Power

The fossil-fuel industries have looked at the above prediction and the inroads contemplated for nuclear power as a real threat to their own existence. They apparently assumed a big loss of market to nuclear power, and have deliberately set up roadblocks to prevent any rapid development. They have tried to eliminate federal sponsorship or subsidy of reactor technology development. However, according to another recent estimate, residents in the United States are expected to use more than four times the amount of fossil fuel in the year 2000 than they are using currently.[3]

The adequacy of fossil fuels beyond 2000 is uncertain. "... Continued compounding of fossil-fuel requirements at the same rate as predicted for the remainder of this century (slightly over 4 per cent per year) would exhaust fossil-fuel resources by the middle of the next century. That time, the year 2050, is within the life span of children now being born. It is therefore expedient that new sources of power be capable of supplying the increase in energy requirements after the turn of the century."[4]

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[1] John F. Hogerton, op. cit., p. 35.

[2] Civilian Nuclear Power ... A Report to The President - 1962, op. cit., p. 11.

[3] U. S. Atomic Energy Commission, Fossil Fuels in the Future, (Washington, D.C., U. S. Government Printing Office, October 1960) p. 1. [4] Ibid., p. 2.

Table 2, below, shows projected world fossil-fuel production schedule in units of Quintrillion British Thermal Units (Q's):[5]

Table 2

WORLD FOSSIL - FUEL PRODUCTION SCHEDULE IN Q

Period	Date of End of Period	Production During Period	Reserves at End of Period
	Dec. 31, 1958		111.02
1959 - 1980	Dec. 31, 1980	3.75	107.27
1981 - 2000	Dec. 31, 2000	7.90	99.37
2001 - 2020	Dec. 31, 2020	18.35	81.02
2021 - 2040	Dec. 31, 2040	41.02	40.00
2041 - 2052	Dec. 31, 2052	40.00	0

Source: Fossil Fuels in the Future[5]

Of all the fossil-fuel industries, coal has waged the most bitter attack against nuclear power. The National Coal Association has claimed that the federal government 'force-feeds' nuclear power. Coal has been the most vocal of all, with the concern shown by gas and oil almost nominal by comparison. No doubt the coal people recall the large gains made against it by the diesel locomotive and the gas pipelines.

Beginning in 1963, the National Coal Association assumed the role of continuing opposition party in AEC reactor licensing proceedings for every nuclear plant proposed for siting in or near a coal-producing area. In that same year the coal lobby was able to bring about decisive budget cuts by the House of Representatives, assisted by congressmen from such states as West Virginia, Pennsylvania, and Oklahoma.

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[5] Division of Technical Information, Fossil Fuels in the Future, U. S. Atomic Energy Commission (Washington, D. C., U. S. Government Printing Office, October 1960) P. 8.

In early 1964 the coal group demanded the Atomic Energy Act be changed, and that assistance to nuclear power be stopped. Coal interests have also asked that a 'finding of practical value' be made for water reactors, since such determination would eliminate further assistance for that type of reactor. The act has not been changed; however, one may note that no water reactor funds have been included in federal budgets for the past two years.[6]

The campaign to date by the coal interests has been the most organized and the most effective, and the Joint Committee on Atomic Energy has been kept busy in a heated debate.

First AEC Chairman David E. Lilienthal now serves as counsel for coal interests, and has spoken out against the safety of nuclear reactors. Although he is a lawyer, and without the required technical background to judge safety criteria, his former AEC role carries much weight with the public. His vocal criticisms of the Ravenswood site and safety of the plant were apparently very effective, as shown in the next chapter. However, most of what he is practicing now is not what he preached in 1949.

Nuclear power has already become competitive in high-cost fossil-fuel areas. An important breakthrough could occur if plants could be located near their load centers, since every additional mile that a plant must be built away from its utility load center requires about $2 million of capital cost in constructing the plant. By creating a furore over plant safety, opponents of nuclear power have kept plants away from populated areas and their load centers. This effort has kept the costs higher to build nuclear plants, and has slowed their competitive ability, and has slowed their development.

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[6] Nucleonics Week, (New York: McGraw Hill, March 12, 1964) p. 2.

In the case of Ravenswood, David Lilienthal and coal led the charge against it on the grounds of safety, and Ravenswood was ultimately dropped by the planner, as shown in the case study in the next chapter.

In the case of the Fermi plant south of Detroit, Michigan, Walter Reuther led the campaign for three labor unions. Organized labor challenged the safety of the plant all the way to the U. S. Supreme Court.

The motives for the actions taken by these intervenors are speculative. The reason suggested in the Fermi case was a presumed need on the part of organized labor to prolong the arrival of mass unemployment that had been promised with a fast breeder type of reactor that could produce more fuel than it consumed. Perhaps more realistic siting criteria in this case would have suggested to the reactor builder that such a revolutionary contraption should not be tried in labor's own stronghold. A chronology of steps taken by both parties, and the events that followed are outlined in a case study, also.

Those who objected to the plant siting at Bodega Bay, California, were primarily the nearby residents who formed a dynamic group to 'protect their property' by protesting the use of the site for a reactor plant because of the possibility of earthquake. This possibility was studied by the planner, and all sorts of measurements were taken by all sorts of specialists in an effort to satisfy the doubts. After complete excavation of the site down to more than 70 feet below ground level, and commitments for long-lead hardware items including the reactor vessel itself, Pacific Gas & Electric Company dropped the plant after it was unable to satisfy doubts about safety that had been expressed by AEC regulatory staff. Numerous hearings had been held, in line with the procedures shown in Chapter IV, and the applicant had incorporated many design changes and had further amended the application in a futile effort to prove safety of the site.

The protests against locating the Malibu Atomic Power Station in Corral Canyon, near Los Angeles, have been sufficient to date to delay building the 463,000 net kilowatt (electrical) plant. Hearings are still being held there, and include protestors such as Lester T. (Bob) Hope, who owns more than two-thirds of the land at Malibu.

The protestors against Dairyland Power Cooperative's nuclear plant to be built at Genoa, Wisconsin, were primarily the fishermen who were unduly concerned about the impact on their fishing sport in the nearby river. The plant is now scheduled to achieve criticality in 1966.

At Consumers Power Company's Big Rock Plant near Charlevoix, Michigan, Local Union 346 of the Utility Workers of America cited the Atomic Energy Commission's strict licensing requirements and program of continuing inspection as a basis for seeking hazard pay for their operators who work in the reactor plant.

A few residents of San Clemente, California posed safety objections at a hearing conducted by an AEC Licensing Board on the nuclear station planned for nearby San Onofre on the basis that liquid and gaseous wastes from such a plant would have a harmful effect upon the people who live nearby, and on the wildlife and ocean flora and fauna. They were heard and their complaints given much notoriety, but ultimately the permit was issued in this case; construction is expected to be completed in 1966.

Under the Atomic Energy Commission's program which invites protests to be heard, even the voice of one man, including any honest citizen with good intentions or a crank can create enough questions and doubts in the minds of several other people, and thereby extend considerable mystery and confusion.

The influence of the opponent group cannot be measured absolutely. Yet by looking at individual cases where a utility firm has invested time and money to plan and often start a major facility and has fought the opposition only to cancel out do we see the impact. Utilities are notoriously sensitive to public opinion. They are also conservative in the moves they make.

The planned thermal output at the Fermi plant was 200,000 kilowatt. At Malibu it was 1,473,000, and at Bodega Bay it was to have been 1,009,000 kilowatt. The Ravenswood plant called for 2,030,000 kilowatt. No one could presume to guess how many firms have avoided the wrangle entirely by not even applying in the first place. Many are simply holding back, awaiting further developments and have continued their planning for added plant capacity along fossil-fuel lines with a non-controversial plant that will produce, in addition to the extra power, quite a bit of fly-ash, smog, smoke, smaze, and haze, and other familiar and 'acceptable' irritants.

B. <u>Proponents of Nuclear Power</u>

The 1954 Act establishes the AEC objective to develop nuclear power technology, and the need for the federal government to provide a proper atmosphere conducive to such development is generally accepted. Financial assistance, reactor ownership, and some research and development help has provided at least a feasible basis on which risks can be shared and some incentive provided for the power industry to 'look into the possibility of new power. The federal government's role as proponent will continue so long as it is needed. If the opponent group continues to thwart those few who would take a bold 'first step' into a risk area, one could forecast that the proponent role of the government will have to continue for a long time.

The power industry's role also falls naturally to being one of wanting to assist the advance of nuclear power technology. Electric power plants are coal's best customers. They also have a heavy investment in air-pollution control equipment. Their best-interests include a desire to learn more of the promised greater benefits and lower costs of nuclear power.

In reply to a 1963 claim by the coal lobby that nuclear power economics are being misrepresented, an unidentified president of a utility firm that operates an atomic reactor sent a letter of rebuttal to the National Coal Association. The letter, which sums up the power industry's views fairly well, is quoted below:[7]

> "...It is possible to engage in some conjecture as to the reason for the worried consternation which prompts the NCA position vis-a-vis nuclear energy, but I submit it is scarcely credible that the thesis you expound will receive serious consideration from anyone conversant with the facts.
>
> "Unfortunately you choose to characterize as 'foolish' the investment of several hundred millions of dollars by private business (and your best customers) in an intelligent, diligent search for better ways to harness energy. It seems somehow reminiscent of a buggy-whip manufacturer shouting 'get a horse!' to the proud operator of a 1-cylinder Brush automobile circa 1901. The Brush (and its cousins) developed into one of the greatest industries in the world. The buggy-whips now are sold only to lion tamers and carnival barkers.
>
> "It is not my purpose to debate the issue with you in this letter; rather, I simply want to go on record in nailing down a few points:
>
> "1. Nuclear energy as a power source is not going to 'go away' -- it is going to continue to develop because the economic promise is not an illusion.
>
> "2. Nuclear energy will not replace coal as our basic fuel for a long time to come but it certainly will penetrate and modify the coal industry's market.
>
> "3. Electric utility people are not 'foolish', incredibly reckless men who disregard the safety of the communities they serve -- and neither are regulatory commissioners.

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[7] Nucleonics Week, (New York: McGraw Hill, October 10, 1963) p. 6.

"4. Electric utility people are not engaged in squandering stockholders' money to build 'high-cost power' plants as devices to 'forestall' public power programs via the nuclear route -- as you assert.

"5. Lastly, the electric utility companies represent the largest single market served by the coal industry and I would suggest that coal people do not endear themselves to their good customers by denouncing said customers as irresponsible witlings.

"Stop wringing your hands... and get on with the business of making your product the 'moving target' bargain you want it to be."

Not all of the above rebuttal fell on deaf ears if one observes the recent influence on the coal industry, notably in the cost economies they have effected through mine-mouth plants and such other innovations as 'liquified' coal slurry pumped via pipeline directly from the mine to the furnaces.

The role of the scientific community is also one of proponent. The new challenge of reactor technology and nuclear physics is an intriguing one, with the usual mechanical problems, exotic equipment design needs, and a host of operating problems. The reactor engineer can withdraw himself from many of the more controversial aspects of this matter to look at the pure data being generated. He is concerned with operating criteria and technical problems, but usually does not generate any data that the non-technical public can assimilate or comprehend. As a proponent, then, the scientific group's influence is therefore indirect and not as effective as it might be. There are memberships in societies and technical groups, and symposia held to discuss progress and exchange views, but these involve separate worlds and a different language than the layman uses. Not until 1963, for example, did the Atomic Industrial Forum begin a program of public understanding.[8] In so doing they have taken positive steps to narrow the distance between two worlds -- the one where scientists work and the one where they live.

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[8] John F. Hogerton, Background Information on Atomic Power Safety, op. cit.

C. The Public

The combined total influence of the public is undoubtedly greater than all of the foregoing groups. Within this group exist most of the wild and inaccurate views about radiation. Public hearings held by AEC Licensing Boards have indicated the serious lack of understanding on the part of the general public of the hazards involved. With the engraved memory of bomb effects overriding in the public's thoughts on nuclear power these misunderstandings will probably continue. In addition, with the tendency for exaggeration and news sensationalism within this industry, there are good indications that the public mind will stay made up for a long time to come.

According to Frank Brannigan, AEC safety engineer: "If there is any one conclusion that can be drawn, it is that no presumptions can be made that there is any understanding of the full nature of the radiation problem at any level of the population. Persons well educated in other fields may grasp the facts sooner than those less well educated, but it is quite safe to start with the basic assumption that little is known, and that little is generally in error."[9]

The parade of witnesses against Bodega Bay, Malibu, Ravenswood, and the others, with the resulting cancellation of large nuclear power plants plus deferment of important planning describes the impact of public influence on these specific projects. Other firms have probably stayed out of any controversy completely. Where there exists a public concern with a program as this one the assumption can be made that a conservative utility approach would be to avoid further irritation of public concern. Such is probably the case today, where many firms have adopted a 'wait-and-see' attitude

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[9] Francis L. Brannigan, *op. cit.*, p. 1.

toward nuclear power. On this basis, what they have been seeing lately will probably cause a longer waiting period before they take any further action to provoke certain public sectors.

The level of opposition to date and the current misunderstandings and disputes over safety are truly significant. Of greater significance is an apathy on the part of an overwhelming segment of the public who couldn't care less. In a further observation by Mr. Brannigan: "It behooves all of us who believe that the peaceful atom offers much to mankind to understand the fears which often underlie the stated objection, or even more insidious than an objection, the inertia."[10]

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[10] Francis L. Brannigan, op. cit., p. 5.

VI. SELECTED CASE STUDIES

The following case studies are given in support of the hypotheses shown in Chapter I. They are believed to illustrate situations in which certain groups have intentionally taken steps to interpose safety objections to deliberately slow the growth of nuclear power.

A. The Enrico Fermi Atomic Power Plant

In December 1950, the Detroit Edison Company together with the Dow Chemical Company submitted a proposal to the AEC to proceed with a feasibility study of a dual-purpose reactor of the 'fast-breeder' type. As will be seen, the breeder type of reactor is a significant technological innovation, for it literally produces more fuel than it consumes. In addition to producing heat for the steam to drive the turbines, it also produces plutonium. This particular concept would be comparable to putting 10 gallons of gasoline in an automobile's gas tank and driving several hundred miles non-stop only to find that the tank now contains 12 gallons of gasoline. Naturally, the consequences of such a feat would be startling, indeed.

The record of events shown below has been paraphrased from the Detroit Edison Company's "Chronological Record of Atomic Power Development Activities," and illustrates the steps taken by the non-profit Power Reactor Development Company (PRDC) group formed to construct and test the reactor, and those taken by certain organized labor groups:[1]

August 30, 1954 - President Eisenhower signed the 1954 Atomic Energy Act to permit private firms to own nuclear facilities.

October 3, 1954 - The President of Detroit Edison, Mr. W. L. Cisler, predicted groundbreaking within 5 years on an atomic generating plant in Michigan.

[1]Detroit Edison Company, Chronological Record of Atomic Power Development Activities, Public Information Department, (Detroit: 1963)

March 30, 1955 - Detroit Edison files a proposal with the AEC to construct a developmental fast breeder reactor.

August 8, 1955 - The AEC accepts the proposal, but the actual site of the plant is not yet announced.

August 30, 1955 - Power Reactor Development Company (PRDC), a non-profit Michigan corporation is formed to proceed with the reactor.

January 6, 1956 - PRDC files an application for a construction permit to build the reactor 30 miles south of Detroit at Lagoona Beach, on Lake Erie.

February 16, 1956 - Mr. Walker Cisler discusses tax, insurance, and other legal problems with the Joint Committee on Atomic Energy.

April 30, 1956 - Grading work is started at the plant site.

June 6, 1956 - AEC and PRDC receive a report from the Reactor Safeguards Committee that insufficient data are available at the time to verify the safety of the planned reactor.

August 8, 1956 - Inaugural ceremonies are held at the site, and the plant is named in honor of Enrico Fermi.

August 31, 1956 - Representatives of three labor unions under CIO file petitions as intervenors against PRDC's conditional construction permit; The UAW (auto workers), IUE (electrical workers), and UPA (paper workers) ask to suspend the permit until a safety hearing can be held. A hearing was later held in Washington, and on January 8, 1957, the petitioners' request for suspension of the permit was denied by the AEC.

January 8, 1957 - PRDC experts testify as to the financial responsibility of the company as well as the safety aspects of the plant.

January 28, 1957 - The unions object to the admission of PRDC testimony.

March 4, 1957 - Hearings are resumed in Washington and PRDC witnesses are cross-examined; the State of Michigan also intervenes to assure that its interests are fully protected.

March 26, 1957 - AEC signs contract with PRDC to waive use charges for nuclear materials used in connection with the Fermi plant.

April 12, 1957 - Union intervenors cross-examine PRDC witnesses at hearings

May 13, 1957 - Union witnesses testify

May 25-26, 1957 - Fermi plant site holds open house attended by more than 10,000 people.

June 27, 1957 - UAW President Walter Reuther and Union Counsel Ben Sigal testify on safety issues and challenge the legality of the contract between AEC and PRDC.

August 16, 1957 - the Senate authorizes $1,500,000 for breeder reactor research.

September 3, 1957 - the first Federal Atomic Indemnity Act is passed to provide up to $500,000,000 for each privately-owned nuclear plant.

October 29, 1957 - Briefs and conclusions are filed by AEC, PRDC, and the unions in connection with the Fermi hearings.

January 1, 1958 - PRDC signs contract with an environmental monitoring firm to test the soil, water, and air in the environment near the plant site to establish background levels.

June 11, 1958 - Union counsel claimed that additional federal expenditures on fast reactor research were illegal and opposed these in a statement to the Joint Committee on Atomic Energy.

June 19, 1958 - PRDC urges approval of AEC's request for $1,500,000 funding.

June 23, 1958 - Construction activity begins on the non-nuclear section of the Fermi plant.

December 10, 1958 - AEC issues an initial decision on the union intervention in PRDC license hearings, and upholds PRDC on almost all counts, and the construution permit for the plant was extended.

January 14, 1959 - Unions file exceptions to the AEC ruling, and renew a demand that the construction permit for Fermi be cancelled.

February 5, 1959 - AEC and PRDC reply to union objections, rejecting them as without any merit and inconsistent with the clear intent of the Act.

May 26, 1959 - AEC issues a final ruling against union intervention on Fermi construction upholding PRDC and continuing the permit.

July 25, 1959 - AFL-CIO initiates suit against the AEC in the U. S. Court of Appeals, asking that the decision to continue Fermi be set aside as illegal.

July 31, 1959 - PRDC files a motion to intervene in the Union's court action.

December 1, 1959 - Fermi non-nuclear components are satisfactorily tested.

December 18, 1959 - Unions file brief as petitioners in the Court of Appeals, questioning the legality of AEC construction permit issued to Fermi. Oral arguments are heard on March 23, 1960, before three judges.

June 10, 1960 - The Appellate Court rules against AEC, and sets aside the permit as illegal in a 2 to 1 decision.

June 17, 1960 - AEC petitions for a re-hearing before the full court of nine judges; PRDC also files and the court order was delayed pending outcome.

July 25, 1960 - Court of Appeals denies the petitions for rehearings filed by AEC and PRDC.

August 12, 1960 - PRDC petitions the U. S. Supreme Court to review and reverse the Appellate Court ruling against Fermi.

August 29, 1960 - AEC and the Department of Justice also file petition for Supreme Court review.

October 28, 1960 - Union files brief questioning legality of AEC permit and also the adequacy of findings on safety of the reactor.

November 14, 1960 - U. S. Supreme Court consents to review Fermi decision.

June 12, 1961 - The Supreme Court reverses the lower court, ruling 7 to 2 that union objections to Fermi had no merit, and "that safety and site findings were entirely adequate, and that the construction permit issued by the AEC complied fully with the law."[2]

July 13, 1961 - PRDC files special summary reports with AEC as a first step in obtaining a license for operation of the reactor.

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[2] Chronological Record of Atomic Power Development Activities, op. cit., p. 28.

December 11, 1962 - AEC schedules public hearing on the Fermi plant, and intervening unions ask for postponement to January 3, 1963.

January 3, 1963 - Atomic Safety and Licensing Board conducts hearings on PRDC's application for an operating license, and denies motions of the union representatives for further delay; Union representatives then physically withdraw from the hearings.

April 16, 1963 - Licensing Board issues favorable opinion and the Unions object to the immediate effectiveness of the order, and request a stay.

May 10, 1963 - Fermi is issued a provisional operating license to operate up to 1 megawatt thermal for a period of 18 months.

August 23, 1963 - Fermi reactor achieves criticality within one-half of one per cent of the predicted critical mass.

As shown by the above chronology, the Fermi plant was the center of many court battles, delays, moves and countermoves, and so on, before it achieved criticality in August 1963, three and one-half years later than the original target date for completion.

One fact not readily apparent from the above record is that every $1,000 of cost incurred by those who intervened probably required 100 times that amount in expense incurred by the PRDC group in defending against the protests that were raised.

Fermi was originally planned for 300 Megawatt thermal capacity; the very low level of 1 Megawatt was agreed upon as an almost humorously low level at which PRDC could get physics data without upsetting the safety criteria. In time PRDC will seek to raise the output to 30 MW and higher; but no one can say whether the $100,000,000 plant will ever operate at full power.

B. The Ravenswood Decision

The chronology on the Fermi plant illustrates how a carefully planned controversy slowed the progress on an important plant once the plant was started with heavy commitments made. Consolidated Edison's decision on Ravenswood presents a different situation.

In November 1963, Consolidated Edison announced plans to build a 1,000 Megawatt (electrical) reactor plant at the Ravenswood site in Queens, Long Island. The announcement was bold in that the plant was to be the first located near a population center, in this case downtown Manhattan. In the past, all utilities had been locating their nuclear plants many miles out in the country, away from any population. The move was highly publicized in the industry and within the New York area. Edison already had three other fossil-fueled plants at Ravenswood, and the added capacity was to be nuclear. The company applied to AEC for a license, and the opposition groups went to work almost at once.

A group of New York Congressmen, made up of James Delaney, Joseph Addabbo, Benjamin Rosenthal, and Seymour Halpern, called themselves the "Queen's County Congressional Delegation." After meeting with AEC to protest the issuing of a license, Representative Halpern commented as follows:

> "We insisted that the safety of the public must be the deciding factor in the AEC's action on the Consolidated Edison proposal for a nuclear power plant in Long Island City (Queens). Our concern, we pointed out, is for the safety of the people of Queens and all metropolitan New York. We stressed to the Commission that in our opinion, without qualification, all other factors must remain secondary. We conveyed the fear that the public has regarding possible dangers of a nuclear power plant in the heart of metropolitan New York. We emphasized that the residents of Queens don't want such a project as long as there is an element of danger. We asked for a complete scientific report on every safety aspect and for the opportunity for the public to be heard on the issue."[3]

[3] Nucleonics Week, op. cit., November 7, 1963., p. 1.

Chairman Seaborg assured the group that every aspect would be investigated, and three full days of hearings would be held at a place close to the proposed site. The Chairman also assured the Congressmen that any economic advantages to Consolidated Edison were not considerations in the issuing of a license, and that safety of the public would be the main objective of the AEC report.

Simultaneously, legislation was also being considered that would give authority to local governing bodies to prohibit construction of nuclear facilities within their boundaries.

Consolidated Edison proceeded with their plans for the plant, and selected an architect-engineer firm. They negotiated with Westinghouse to build the reactor, which was to be completed in 1970.

Certain groups who were either unduly concerned about their land value or their health, or something, raised loud protests against the project. Former AEC Chairman David E. Lilienthal spoke for the coal group, and went on record as saying "I would not live next door to the atom" in a speech at Yale University in October, 1963. He was highly critical of the Ravenswood plant, and the viewpoint was widely quoted by the press.

Within a few days, present Chairman Glenn Seaborg spoke before Sigma Delta Chi at Norfolk, Virginia, on the subject: "Why Nuclear Power?"[4] He observed that nuclear power plants do not place hazardous combustion products into the atmosphere, and again emphasized that very little of the radioactivity from a nuclear reactor ever gets into the atmosphere. Any such release is always carefully controlled, and does not add very significantly to the ever-present levels of radiation already there.

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[4]Remarks by Dr. Glenn T. Seaborg, Chairman, U. S. Atomic Energy Commission, at the National Convention of Sigma Delta Chi, Norfolk, Virginia, November 7, 1963.

Dr. Seaborg observed further that AEC has followed what it believes to be a mandatory policy of ultra-conservatism with respect to public health and safety. Although he did not refer specifically to the earlier speech by Mr. Lilienthal, the Chairman summarized his own feelings about safety of power reactors by saying: "I would live next door to the atom."

Former Chairman Lilienthal immediately attacked the speech as indicating a prejudgment of the safety of Ravenswood before any hearings were held on the subject of safety of the plant. The controversy continued, the hearings were held, and the applicant firmly held on to his plans to build a plant.

On January 7, 1964, however, the company surprised everyone involved when it announced that it had withdrawn its application to AEC for license approval to begin construction of the plant.[5] Company officials denied that any pressure from the opposition had anything to do with their decision, and insisted that their choice to obtain substitute power from Canada was determined by the economics of the situation. From its inception, the planned $175 million project had lasted 13 months.

Consolidated Edison discussed their decision, and made it clear that "...To a greater degree than most nuclear power plant projects, because of the challenge implicit in its proposed site, the Ravenswood reactor project was contingent upon getting AEC licensing approval. Yet the timing of [the] announcement of withdrawal was ironic, even unfortunate in some respects. For one thing, Con Edison had declared early last year [1963] that regardless of the comparative economic aspects of the Labrador hydro scheme ... the company intended to stick with the Ravenswood project at least through the stage of getting an AEC decision on licensing approval.

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[5] The Wall Street Journal, January 7, 1964, p. 1.

The Con Edison action now deprives the nuclear power industry not only of a potential active project of record size, but also even of an AEC benchmark decision that would have indicated AEC's position on reactor siting within large cities and what credit for engineered safeguards in place of distance AEC's safety experts are willing to grant in the present state of the art."[6]

The above article also discussed the irony of the timing of the company's announcement, since it was made just after Westinghouse had determined that a 1,000 Megawatt (electrical) nuclear reactor plant was feasible. David Lilienthal, who had strongly opposed Ravenswood, hailed the decision as one that "affects the whole future of nuclear power in urban centers throughout the United States."[7]

In the Ravenswood effort, Consolidated Edison had not signed contracts, but Westinghouse had incurred costs of nearly $500,000 in getting ready for the project. The claims from the opposition groups were that Consolidated Edison has backed down under pressure.

Almost 14 months after the decision to drop the plant, Mr. M. L. Waring, a Senior Vice-President of the firm, announced that: "...Widespread adoption of nuclear power is going to take time, and that public acceptance particularly, insofar as metropolitan areas are concerned, is as much a factor in this as economics; we are convinced that nuclear power plants can be built and operated safely in New York City... There are few places where nuclear power is so desirable and so needed."[8]

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[6] Nucleonics Week, op. cit., January 9, 1964, p. 1.

[7] Ibid., p. 2.

[8] Ibid., March 4, 1965, p. 3.

He also criticized the number of hearings, regulations, safeguards, insurance requirements, siting criteria, and safety philosophy for nuclear power plants.[9] Thus, more than a year after the Ravenswood decision the observers obtained a better picture as to why Consolidated Edison really dropped their plans for a nuclear license at the Long Island site.

C. The Bodega Bay Decision

The Pacific Gas & Electric Company was one of 8 companies forming a study group appointed to look at nuclear power potential. The Dresden Nuclear Power Station, near Chicago, was successfully sponsored by this group. Pacific Gas & Electric later pioneered other plants at Vallecitos and Humboldt Bay, California, and is participating in an advanced design nuclear plant at Peach Bottom, Pennsylvania. With considerable atomic experience behind it, the company announced in late 1962 that it planned to build Bodega Bay "Atomic Park."

The company had acquired 225 acres at the tip of Bodega Head, north of San Francisco. The reactor plant was supposed to occupy a small part of the site with the balance to be developed for picnic and park areas, hiking trails, and view landscaping on the barren headland. The 325,000 kilowatt plant was to cost $61 million and was going to be Pacific Gas & Electric's largest atomic power project. The plant would serve a city of half a million people. Company brochures referred to Bodega Bay as "The Big Step" -- and indicated that, after 1970, most of the major generating plants that the company would add on to the system would be nuclear-powered.[10]

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[9] Nucleonics Week, op. cit., March 4, 1965, p. 3.

[10] Pacific Gas & Electric Company, Electricity From Atomic Energy, July 1964.

In November 1962 the California Public Utilities Commission granted the company a certificate of public convenience and necessity. Again a familiar pattern developed. Almost immediately questions were raised by some about the ability of the plant to withstand earthquake conditions. The location of the San Andreas fault in the area was well-known, and the results of the 1906 earthquake on nearby San Francisco were clearly recalled. Questions were raised concerning the geology and seismology of the plant site, and the company carried out extensive excavations on their own initiative and before a construction license was issued. They were hoping, of course, to clearly establish the suitability of the bedrock foundation.

A host of intervenors sprang up in the area, including homeowners, landowners, conservationists as well as conversationists, a few cranks, and others. A group was organized and called itself "The Northern California Association to Preserve Bodega Head and Harbor." Efforts on both sides were increased. The company continued to obtain more and more geology and seismology data about the site from highly-qualified scientific consultants, and Bodega Bay opponents continued to argue against the project. By August 1963, Lt. Governor G. M. Anderson sent a letter to AEC and objected to the licensing of the reactor. His objections were twofold: (1) The reactor would spoil the natural beauty of the Bodega Bay area, and (2) Split opinions existed on the safety question.[11]

The state's Public Utilities Commission, however, had granted to the company a certificate to go ahead with the reactor, and stubbornly refused to listen to the complaints or reopen hearings for any further proceedings. PG&E hired more consultants and proceeded on their own to prove suitability

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[11] Nucleonics Week, op. cit., September 12, 1963, p. 2.

of the site. By October 1963, they had completed excavations to a point 73 feet below sea level, and had obtained several independent evaluations from well-qualified people that the site was safe. Shortly thereafter, a fault was discovered in sediments above the bedrock and was later determined to extend into the bedrock itself. More controversy followed, although none of the evidence uncovered indicated that any movement had occurred along the geologic fault in the last 10,000 years.

In January 1964, U. S. Department of Interior geologists reported that any earthquake activity as severe as that experienced in 1906 could be expected to cause displacements of a few feet somewhere on Bodega Head. A little while later PG&E sent out its own geologic report prepared by independant consultants. The PG&E report concluded that the foundation was amply strong and suitable for the proposed plant.[12]

A second report, by Hugo Benioff, professor of seismology at California Institute of Technology, described Bodega Bay as an excellent location since the reactor could be deep-seated in granitic rock where any probability of earthquake damage would be very remote.[13] Nevertheless, criticisms continued, but PG&E emphatically denied any possibility they would change their plans to locate the reactor at Bodega Bay.

In March 1964 the California Supreme Court ruled against the opponents of the plant who had asked that public hearings be held concerning the permit granted by the state. That same month, two University of California geologists, G. H. Curtiss and J. F. Evernden admitted that they had been emotionally biased against the site, but after having visited it they were

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[12] Nucleonics Week, op. cit., February 6, 1964, p. 3.

[13] Ibid., p. 3.

now convinced of its safe use. They observed that: "No major displacement has ever taken place within the site area and none is to be expected in the near future." Minor displacements "have not occurred within more than 40,000 years, have occurred only a few times within the past 90,000,000 years, and would not dangerously affect the reactor if they did occur."[14]

In a letter to the company in May 1964, the AEC raised certain questions concerning the ability of the Bodega reactor to withstand certain earthquake conditions. The company re-examined the situation and replied that independent experts had determined that any movement beyond a fractional inch was most unlikely, and any movement exceeding one foot was very near impossible. They said further: "To assure, however, that no reasonable question can be raised as to the safety of the plant from possible seismic activity in the area, the company has modified the design of the plant to withstand several feet of differential ground motion."[15]

During this same period the Alaskan earthquakes occurred, causing much damage and suggesting to many Californians that similar results could occur in their own state. However, Bodega Bay's site is located in bedrock; in contrast, the loose gravel around Anchorage resulted in much aggravated damage from landslides.

PG&E provided additional assurances to AEC in October 1964, observing that substantial margins of safety would be built into the plant, and that it could be safely shut down and any accident contained in the event of earthquake activity such as within the magnitude posed earlier by the AEC. The State of California announced that it was planning to hold hearings in Sacramento on the Bodega Bay proposal.[16]

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[14] Nucleonics Week, op. cit., March 26, 1964, p. 5

[15] Ibid., August 20, 1964, p. 5.

[16] Ibid., October 1, 1964, p. 5.

On October 27, 1964, the AEC released contradictory reports. The Advisory Committee on Reactor Safeguards agreed that the plant could be built and operated without undue safety hazard, but the Division of Reactor Licensing concluded that the site was not a suitable location.

On October 29 Governor Pat Brown was questioned about the reports, and he answered: "...My immediate reaction was that if there was any question on safety at all, the PG&E better abandon that site and go to another one. It's just one of those that I don't think we can take any chance on it at all. If there's any danger in it or say a majority say it would be safe but a minority say it would be unsafe, let's get out of it. This nuclear danger is so great that you can't take any chance whatsoever. And my immediate reaction is to say to PG&E: 'Let's go someplace else.' "[17]

On October 30 the company issued a statement of its withdrawal from the site, saying in part: "...We have repeatedly stated that if any reasonable doubt exists about the safety of the proposed Bodega plant, we would not consider going forward with it... The regulatory staff of the AEC, however, has recently reported that it has some doubt 'at the present state of our knowledge' about the capability of the structure to withstand the maximum assumed earthquake. Although agreeing that the 'proposed engineering principles appear reasonable,' the staff has expressed concern over the lack of an experimental or experience proof-test of them. The doubt raised by the staff, although a minority view, is sufficient to cause us to withdraw our application. We would be the last to desire to build a plant with any substantial doubt existing as to public safety."[18]

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[17] Nucleonics Week, op. cit., November 5, 1964, p. 1.

[18] Ibid., p. 2.

The unfortunate decision came, of course, only after Pacific Gas & Electric was well along the path and after they had ordered several long-lead hardware items including the reactor vessel itself. There was no indication of the expense incurred by PG&E in pursuing Bodega Bay. But the dropping of the project was of further serious concern to many in the nuclear business, including the Japanese, who have their own reactor programs going and have also their own vulnerability to seismic disturbances.

The State of California decided to hold its hearings anyway, to gain testimony on siting problems involving nuclear facilities, and to find out whether the state should take a more active role in zoning and regulating nuclear installations.[19]

Pacific Gas & Electric Company later leased the land to the county at $1 per year for the 200 acres as park land. The company will retain the 25-acre tract and the excavated area, perhaps for some scientific use as diving or seawater tests. The high cost of bringing in oil or gas to the site would prevent the plant from ever being completed for conventional fuel use.

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[19] Ibid., p. 2.

VII. OTHER RECENT DEVELOPMENTS

In addition to the actions taking place at Fermi, Ravenswood, and at Bodega Bay, some of the other events and developments that have occurred include the following:

A. NS Savannah Experience

After overcoming numerous setbacks and delays including a complete labor walkout of her crew, the nuclear ship "Savannah" finally started on her world tour in 1964. Early concerns with a nuclear ship involved hazards at sea as well as the need to protect crew and passengers from radiation. But these were overcome, and adequate safeguards were engineered into the ship's design.

By June 1964 the NS Savannah arrived in New York harbor where the vessel was hailed as an important step forward in marine technology. Her presence there under nuclear power nevertheless recalled to many a 'Ravenswood-type' of situation and the fact that original AEC siting criteria had not covered situations where a nuclear ship might move in and out of large population areas. Negotiations proceeded with several foreign governments for visits. The hope was, as predicted by AEC Chairman Glenn Seaborg, that the Savannah would someday become a 'free ship,' able to enter any port in accordance with appropriate local regulations, but without cumbersome review by any governmental regulatory bodies at each port of call.[1] Meanwhile, the ship is going along her way, enjoying greater cargo capacity, higher speeds, lower fuel costs, and a five-year supply of fuel. Hopefully, much of the public concern and regulations will expire before she does, and another important step forward can be gained in the area of public acceptance.

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[1] Nucleonics Week, op. cit., June 11, 1964, p. 2.

B. The Thresher Disaster

The USS Thresher (SSN593) was lost in the Atlantic off Cape Cod on April 10, 1963. This unfortunate accident for a while involved speculation that the submarine's nuclear reactor may have exploded and caused the sinking. What actually happened will probably never be known for sure, but the integrity of the boat's power plant was not believed to have been a factor in the accident, according to U. S. Navy findings. Aside from the tragic loss of the ship's entire crew, the accident was probably subject to added publicity and more of an 'aura of mystery' since it was fueled by nuclear power. Publicity such as this usually causes the image of nuclear power to take two giant steps backward in the public mind.

C. Other Developments

In April 1964 the Los Angeles County Board of Supervisors overruled the approval of a construction permit granting a Los Angeles utility permission to use the Malibu site to build a 490 Megawatt (electrical) reactor there. The decision came just after a contract had been awarded for $71 million to erect the plant. Mr. Samuel Yorty, the Mayor of Los Angeles, charged the board with reverting to horse-and-buggy days. He announced his total disappointment, and complained that whenever progress is a factor, "...You always find little groups who stir up opposition, preach fear and obstruct progress. They are particularly against those things they don't understand."[2]

In June 1964 the first Polaris submarine, the "George Washington", came in for refueling after almost four and one-half years on one fuel charge. The submarine will be refueled and overhauled in 1965.

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[2] Nucleonics Week, op. cit., June 18, 1964, p. 2.

In October 1964 "Task Force One" returned to the United States after sailing around the world in 65 days without any replenishment. "The three-ship, 12-reactor fleet demonstrated beyond the shadow of any further doubt what had already been clear to most: that nuclear propulsion for naval vessels offers advantages of endurance, autonomy, reliability, sustained speed, acceleration-deceleration and all-around performance that cannot be matched, or even approached, by equivalent oil-fired ships."[3] The Navy had already announced that it would seek nuclear engines for all ships above 8,000 tons. However, the subsequent difficulty in obtaining approval for a second nuclear carrier, its subsequent disapproval, and Secretary Korth's resignation are well-known.

Commonwealth's Dresden Nuclear Power Plant in Illinois has now operated four and one-half years, and the company is very pleased with the results. The plant, which cost $51,100,000 was built 50 miles southwest of Chicago, near the Kankakee and DesPlaines Rivers. The Dresden plant is still the largest nuclear plant in operation in this country. One could imagine the fol-de-rol the company probably would have had to put up with if they had attempted 5 or 6 years ago to locate the reactor near Edison load centers, say on Chicago's south side!

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[3] Nucleonics Week, op. cit., October 15, 1964, p. 3.

VIII. SUMMARY AND CONCLUSIONS

A. Summary of Influence of Safety Philosophy on The Industry

Appendix A provides a list of civilian reactors that are operable, now being built, or planned. The record shows that several prototypes are in operation, and these are proving out various reactor concepts for later incorporation in large central station power plants. However, where the utilities have tried to move into such large central station plants to use the new technology they have gained, they have been often thwarted, as shown in the preceding chapters. Of the four reactors planned in the large power plant category, Bodega Bay was cancelled, and Malibu at present is running into serious opposition. During the 13 months the Ravenswood project ran it was not included among the 4 being planned, but it has been cancelled, also.

The opponents have tried to prevent any federal assistance toward the development of reactor technology; having failed that, they have used the stringent siting criteria and ultra-conservative safety concepts to create doubts and prevent extension of the nuclear power operation in several specific instances. By comparison, in law, if a man brings a suit against a defendant that consists of a cause of action that is totally foolish, the defendant may petition the judge to dismiss the suit and this is usually done. The same is not true in licensing hearings, where any opponent may have his say incorporated into the record.

The conservative attitude of utility firms and their sensitive nature to the force of public opinion will continue to be an important factor in the development of nuclear power for a long time to come. In contrast, Appendix D outlines the results of a public opinion poll taken by Consolidated Edison before and during the construction of its Indian Point plant.

B. Conclusions on The Future of The Industry

Based on the foregoing evidence, the conclusion reached is that while nuclear reactor safety philosophy has established a closely controlled set of procedures and limits for the construction and safe operation of nuclear power plants, it has also provided the complex framework within which the opposing forces have been successfully able to slow the progress of power plants. Only a relatively small group of people are actively interested in advancing the nuclear technology discussed here, and there are many more than this in the opponent groups who are well-organized and actively trying to stop any advances of nuclear technology into their spheres of interest.

Less regulation and time-consuming procedures would aid significantly the development of nuclear power. The history of Bodega Bay, Ravenswood, Malibu, and Fermi and others in the record not only point out a specific loss of new plants, but one may also conclude that others watched these developments and proceedings very closely, and are probably not as likely to move into a similar public opinion trap. There now exist in the record a few unfortunate precedents. There are current estimates that the total safety precautions and added effort add on from one to one and one-half million dollars to the cost of each new plant, thus decreasing any cost attraction it might otherwise have.

Accidents in any nuclear activity are exaggerated in the reporting, and are often attributed to the nuclear power industry in particular. Once it is obtained, the factual rebuttal is not published like the original protest.

Insofar as the rules established for safety reviews and licensing procedures are concerned, they are 'good' in the sense that where they have been followed no serious accident has occurred. In time one might expect that they may be relaxed a little. But in the meantime there is no change in the forecast. If any change does occur in safety regulations within the near future, it could best occur in the area of siting criteria, on the basis that, if other controls are held firm, the plant site could be moved closer to population centers. However, without such change, one may expect that utility firms who add new power to their system will have to inch up gradually on their load centers.

The federal government will undoubtedly contunue to aid and stimulate growth and development of this infant industry but at the same time will insist on maintaining the strict regulations and cumbersome procedures that have grown to be so costly. There are several reasons why the world may not expect to see an energy transformation such as made from wood to coal in the nineteenth century, or as observed in the rapid transition to liquid fuels after World War I. Nuclear power only replaces other fuels as a less costly means of generating electricity, so it simply is not destined to have the sudden impact that other changes have had in the past.

There always have been opponents to new technology, and a few cranks, but in the case of nuclear power they are making themselves heard these days. In time, the successful demonstration of accident-free nuclear plants will show that there are, in fact, relatively few hazards involved. But should any accident occur, one could predict that it will be publicized widely.

An immediate program of public understanding can also make headway in the struggle against fears and anxieties associated with nuclear power. And sooner or later the destined role for civilian nuclear power will suddenly become apparent, including the advantages and incidental benefits to be gained, and will gain public acceptance as the truly wonderful discovery that it actually is.

The major thesis presented here is that nuclear power safety philosophy has influenced industry growth. The assumptions in Chapter I are based on economic and other data shown in "Civilian Nuclear Power ... A Report to the President - 1962." Supporting data were not provided for these assumptions. In assuming that nuclear power shall be economically competitive and indispensable, the assumptions actually support the major thesis in that development of nuclear technology and a capable industry is a good and worthwhile effort to be actively sought after.

Any challenge which unduly tries to slow or thwart the growth of such a worthwhile industry is wrong and should therefore not be allowed. As already shown, several plants have been cancelled.

Nuclear reactor safety philosophy has no historical parallel in the safeguards that have been engineered and the efforts that have been and are being made to assure that no consequential accident can ever occur. But at the same time no significant effort has been made to convince the opinion leader segment of the public that such is the case. The paradox is that tremendous efforts have been made to set up effective criteria for safety, yet these same efforts have induced the wrong kind of interest toward negative aspects rather than toward the positive benefits.

The assumptions in Chapter I define the framework within which growth has been examined for the significant variables. If the assumption had been made that nuclear power would never be competitive, there would not be any need to look at challenges to safety aspects since the economic disadvantages of nuclear power would be self-eliminating for the industry. However, by assuming the opposite, a more realistic insight can be gained into the capricious and harmful nature of 'safety' challenges against nuclear power.

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APPENDIX A

STATISTICAL SUMMARY OF REACTORS IN THE UNITED STATES

	Operable	Being Built	Planned
I. Civilian Reactors			
1. Power Reactors			
Large Power Plants..................		2	4
Prototypes, Central Station Plants..	13	2	
Prototypes, Maritime Propulsion.....	1		
2. Experimental Power Reactors			
Generating Electricity..............	5	1	
Token Electrical Production.........	3	1	2
Advanced System Experiments.........		4	
Space Propulsion Experiments........		*	*
Auxiliary Power for Space (SNAP)....	2	2	2
3. Test, Research, and Teaching Reactors			
General Irradiation Test............	4	1	
Special Test........................	11	2	3
Research............................	35	10	4
Teaching............................	41	1	10
II. Military Reactors			
1. Defense Power-reactor Applications			
Remote Installations................	4	1	1
Naval Propulsion Reactors...........	58	42	
2. Developmental Power Reactors			
Experiments and Prototypes..........	1		1
Naval Propulsion Prototypes.........	6	1	
Aircraft Propulsion Experiments.....			
Missile Propulsion Experiments......	1		
3. Test and Research			
Test................................	3	1	
Research............................	7	1	1
III. Production Reactors			
1. Materials Production.................	14		
2. Process Development..................	4		
3. Test.................................	2		

Source: Division of Reactor Development, *Nuclear Reactors Built, Being Built, or Planned in the United States as of June 30, 1964*, U. S. Atomic Energy Commission, (Washington, D. C., Division of Technical Information, 1964) p. 3.

APPENDIX B

STATUS OF CIVILIAN REACTORS BEING BUILT, PLANNED, AND OPERABLE

Owner or Name of Plant	Plant KW (e)	Reactor KW (t)	Start Up
Being Built (Large Power Plants)			
Connecticut Yankee Atomic Power Station	462,000	1,473,000	1967
San Onofre Nuclear Generating Station	375,000	1,210,000	1966
Planned**			
Bodega Bay Atomic Park	313,000	1,008,000	1967*
Malibu Nuclear Plant	463,000	1,473,000	1967
Nine Mile Point Plant	500,000	1,538,000	1968
Oyster Creek Nuclear Power Plant	515,000	1,600,000	1968
Operable (Prototypes Only)			
Shippingport Atomic Power Station	60,000	231,000	1957
Dresden Nuclear Power Station	200,000	700,000	1959
Yankee Nuclear Power Station	175,000	600,000	1960
Big Rock Nuclear Power Plant	72,000	240,000	1962
Elk River Reactor	23,000	58,200	1962
Hallam Nuclear Power Facility	75,000	240,000	1962
Indian Point Unit No. 1	255,000	585,000	1962
Carolinas-Virginia Tube Reactor	17,000	64,000	1963
Enrico Fermi Atomic Power Plant	60,900	200,000	1963
Humboldt Bay Power Plant, Unit No. 3	50,500	165,000	1963
Piqua Nuclear Power Facility	11,400	45,500	1963
Boiling Reactor Nuclear Superheat Project	16,300	50,000	1964
Pathfinder Atomic Power Plant	58,500	188,900	1964
Being Built			
Peach Bottom Atomic Power Station	40,000	115,000	1965
LaCrosse Boiling Water Reactor	50,000	165,000	1966

Source: Nuclear Reactors Built, Being Built, or Planned in the United States as of June 30, 1964, U. S. Atomic Energy Commission. Washington: Division of Technical Information, 1964. p. 5.

* Dropped by the planner

** Ravenswood does not appear since it was dropped in January, 1964.

APPENDIX C

SUMMARY OF REACTOR ACCIDENTS IN THE UNITED STATES:

January 3, 1961 - The SL-1 reactor located at the AEC's National Reactor Testing Station in Idaho experienced a severe nuclear excursion when a control rod was manually withdrawn from the reactor by a technician. Three men were killed in the accident, which was of a type that could not occur in any central station nuclear power plants.

Other - "There have been two other criticality accidents in U. S. experimental reactors, and a limited number of other adverse incidents (such as partial fuel meltdowns due to improper coolant flow) have occurred in U. S. experimental, production, and test reactors; but none of these occurrences resulted in physical injury to plant workers or exposed the general public to radiation levels above the limits defined by radiation protection standards."

"Apart from the technicians who died in the SL-1 accident, only three deaths have occurred in the United States as a result of nuclear accidents. Two of these occurred in critical experiment facilities used for weapons research, and the third occurred in a chemical processing plant."

Source: John F. Hogerton, Background Information on Atomic Power Safety, op. cit., p. 50

APPENDIX D

SUMMARY OF RESULTS OF PUBLIC OPINION POLL TAKEN AT CONSOLIDATED EDISON'S INDIAN POINT ATOMIC POWER PLANT: *

Question:"Is the plant at Indian Point a good idea?"

	1955	1960
Good Idea	60%	63%
Not a good idea	7	5
Don't know, qualified	33	32

Question: "Do you feel there might be any danger to the community or you personally from this plant?"

	1960
Yes	12%
No	57%
Don't know	31%

Question: "In the event of a question regarding the safety of an atomic power plant, in the opinion of which of these would you have the most confidence?"

A member of the AEC	53%
A prominent physicist	17
A Con Edison official	11
A prominent doctor	10
A prominent biologist	4
A prominent clergyman	4
A newspaper editor	2
A congressman	2
A senator	1
None	3
Don't know	14

*Source: Public Attitude Toward Con Edison's Atomic Power Plant, November 1960.

Question: "Do you happen to know if anyone or any group sets safety rules for the disposal of atomic wastes from atomic power plants? Who?"

Yes		23%
	AEC.....18%	
	Other... 5	
No		77%

The study found that awareness of this particular regulation had a positive influence on the favorability toward the plant. A higher degree of favorability was found among those respondents who were aware of regulation than among those who were not aware, as shown below:

	Good Idea	Not A Good Idea	Quali-fied	Don't know
Aware of Regulation	80%	5%	4%	11%
Unaware of Regulation	57	5	3	35

The conclusion from the above is that it would be advantageous to increase public awareness to the role of the Atomic Energy Commission in regulating nuclear power plant waste disposal procedures and in setting standards for atomic power plants.

The study also showed that 85% of those who had seen pamphlets or visited the plant thought it was a good idea; Of those who had never seen pamphlets or visited the plant, only 60% thought the plant was a good idea.