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The AEC Decision-Making Process and the Environmental: A Case Study of the Clavert Cliffs Nuclear Power Plant

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Daniel A. Bronstein*

The AEC administrative process regulates nuclear power plants in two stages: the first stage results in a construction permit, and the second, an operating license. The commitment of resources at the construction stage is so great, however, that the AEC and the industry become increasingly unable to modify the proposal. Thus, the final decision to license normally becomes almost perfunctory. This case-study first analyzes the industry's decision to build a nuclear power plant. It then illustrates how the AEC process of granting approval of construction permit fails to consider environmental objections except for the most serious hazards to public health. This Article also notes that those objections submitted by governmental agencies, as well as those of concerned citizens, may be ignored.

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This Article is adapted from a paper submitted by the author to the University of Michigan Law School in partial fulfillment of the S.J.D. degree.

Most of the research for this Article was in the form of personal interviews, most of them tape-recorded, with participants in the Calvert Cliffs controversy. Interviews were also arranged with organizations not involved with the principal case for the purpose of comparing the methods of Baltimore Gas & Electric Company (BG&E) with those of other utilities. The Detroit Edison Company was used as an example of other privately owned utilities, and the Hydro-Electric Power Commission of Ontario (Ontario Hydro) and the Tennessee Valley Authority (TVA) were used as examples of "quasi-public" utilities. These comparison organizations were studied by the same interviewing techniques.

A complete list of the people interviewed and corresponded with can be found in Appendix A. Their generous help and cooperation are hereby acknowledged.
The recent Court of Appeals decision in the Calvert Cliffs case adds the requirement that the AEC accord sufficient weight to environmental factors in reaching its decisions. The case will not significantly alter the administrative procedures reviewed here although it will force the AEC to consider an additional factor—the environment—in its decision-making process.

Much has been written about the legal aspects of environmental problems. Suggestions for new structures, mechanisms and controls of decision-making have proliferated, but most of them are either too narrow or too broad, and prove to be outdated by the time they appear in print. In this Article, the author has attempted to avoid the same trap.

This Article analyzes one dispute over the ecological impact of a nuclear power plant and indicates the flaws in and the harmful results of the governmental and private decision-making structures responsible for resolving the dispute. The author hopes to stimulate similar studies of specific disputes in order that a body of empirical, analytical literature might emerge to serve as a basis for judging future attempts at all-encompassing reforms.

This Article studies two aspects of the decision-making process that resulted in the application for, and granting of, a permit to the Baltimore Gas and Electric Company (BG&E) to construct a nuclear power plant in the Calvert Cliffs area of Maryland. These aspects are, first, BG&E's internal decisions to expand its capacity, to "go nuclear," and to locate at Calvert Cliffs, and second, equally important from an environmentalist's viewpoint, the procedures within the Atomic Energy Commission that resulted in granting the construction permit. The focus is not on the presently applicable law, but on the then-existing administrative machinery responsible for AEC decisions. The study illustrates the flaws in the decision-making process that can result in the AEC's failing adequately to protected the public interest in the preservation of the environment.

It is important to note that during the time the AEC was considering the Calvert Cliffs plant, legislation was being enacted to give environmental factors greater consideration in decision-making by federal agencies. On December 3, 1970, almost one year after the National Environmental Policy Act of 1969 (NEPA) became effective, the AEC published Appendix D to its governmental regulations, estab-

1. See Like, Multi-Media Confrontation—The Environmentalists' Strategy for a "No-Win" Agency Proceeding, 1 ECOLOGY L.Q. 495 (1971) for a discussion of utilizing publicity as a lever to induce concessions from the AEC and the utility during AEC construction permit hearings.
lishing procedures which were intended by the AEC to comply with the requirements of the Act. A Calvert Cliffs public-interest group, concerned about the decision-making procedure being followed for the Calvert Cliffs facility, immediately filed two suits: the first challenged four aspects of the AEC Appendix D rules; the second challenged the application of the rules in the granting of the construction permit for the Calvert Cliffs plant. The Court of Appeals for the District of Columbia Circuit in Calvert Cliffs' Coordinating Committee, Inc., v. AEC interpreted NEPA as requiring that “federal agencies [including the AEC] consider values of environmental preservation” and as prescribing “certain procedural measures to ensure that those values are in fact fully respected.”

The court held that AEC's procedural rules did not comply with Congressional policy and that the Commission must revise its rules so as to consider environmental issues. On September 9, 1971, the AEC complied by publishing a revision of Appendix D, which was subsequently amended on September 30, 1971.

Since these lawsuits were not appeals from the granting of the construction permits discussed in this Article, but were completely sep-

4. Calvert Cliffs' Coordinating Committee, Inc.
5. In Docket No. 24,871 (D.C. Cir. 1971), the petitioners challenged four aspects of the AEC regulations: (1) The AEC hearing board was not required to consider environmental factors unless affirmatively raised by outside parties or staff members. 10 C.F.R. § 50, app. D, at 249. (2) The AEC hearing board was prohibited from considering environmental issues at proceedings officially noticed before March 4, 1971. Id. (3) “With respect to those aspects of environmental quality for which . . . standards and requirements have been established by authorized Federal, state and regional agencies, . . . certification by the appropriate agency that there is reasonable assurance that the applicant for the permit or license will observe such standards and requirements will be considered dispositive . . . .” Id. (4) The AEC did not require that action be taken in response to environmental studies and reports made, as required by NEPA, for facilities licensed for construction, but not operation, prior to the effective date of the Act. Id.
6. In Docket No. 24,839 (D.C. Cir. 1971) the petitioners challenged the application of the fourth aspect of the AEC regulation, supra note 5.
7. — F.2d —, 2 ERC 1779 (D.C. Cir. 1971).
8. 2 ERC at 1780.
9. Id. at 1793.
10. Id. Apparently, the new rules foisted upon the Atomic Energy Commission by the court will not affect the construction of approximately forty-five other nuclear power plants being constructed across the United States. In ruling not to halt construction of the Trojan nuclear plant in Oregon, the AEC said that the construction may continue until the final environmental impact statement is completed. Thus, even though the AEC stated that it will review each plant development separately, it has indicated that its new environmental review procedures might not halt nuclear plant construction to the extent feared by the power industry. Wall Street Journal, Nov. 15, 1971 (West Coast ed.), at 10, col. 1.
arate, the Court of Appeals decision has not affected the current status of the Calvert Cliffs plant. Construction on the plant is proceeding—as of November, 1971, the plant was approximately seventy percent completed and BG&E hoped to begin testing in the fall of 1972. The Court of Appeals decision will, obviously, affect the Calvert Cliffs plant when the operating license comes up for consideration.

A study of the AEC procedure, such as this Article, can illustrate flaws and weaknesses in the decision-making process that result in the AEC's failure adequately to consider and to protect the public interest in safety and in the ecological balance. Part I entails a brief description of the plant, its operation, and its environs. Parts II and III describe the internal decision-making processes of BG&E and the AEC, respectively. The study concludes with a statement of the several problems encountered in an unfortunate administrative structure.

I
DESCRIPTION OF THE SITE AND PLANT

The site of the Calvert Cliffs plant is an 1135-acre tract on the western shore of the Chesapeake Bay in Calvert County, Maryland. It is part of an exurban area of the state known as "Southern Maryland." The dominant land use is agriculture, with scattered summer residences along the bay shore. Aside from agriculture the principal local sources of income are the oyster and crab industries and, in the summer, tourism. The site is 45 miles southeast of Washington, D.C., and 60 miles almost due south of Baltimore, BG&E's main load center. The nearest accessible sizeable load center is Annapolis, 38 miles to the north. The cliffs upon which the plant sits are 45-foot-high sedimentary bluffs of the type found along the eastern seaboard from Maryland north to Massachusetts.

The plant consists of two pressurized water reactors (PWR) using enriched uranium dioxide fuel and designed for start-up operation at 2440 megawatts thermal (MWT) or an electrical output of 837 mw each. BG&E expects to complete the first unit between April 13. Telephone conversation with Public Relations Dep't, BG & E, Dec. 20, 1971.
15. A complete list of abbreviations used in this Article is contained in Appendix D infra.

At the time of the design discussions, 1966, this was considered a fairly large reactor. See, TVA, Comparison of Coal-Fired and Nuclear Power Plants, 1966. Now this would be considered a medium-sized installation.
1, 1972, and April 1, 1973, and the second unit the following year. The company anticipates that by 1975 each of the units will be producing about fourteen percent of the total capacity of the BG&E system.

The Calvert Cliffs design is that of a typical pressurized water reactor installation. Figure 1 is a schematic diagram of an 800,000 kw PWR plant, the size of each of the Calvert Cliffs units. As the diagram indicates, there are three separate water circulation systems. The first, the primary coolant loop passes through the reactor core. It contains water at very high pressure (hence the term Pressurized Water Reactor) which serves as the heat transfer mechanism from the heat source, the reactor core, to the steam generator. Due to the high pressure, the water inside this loop does not boil even though heated to a temperature of over 500°F. Inside the loop, tritium, a radioactive form of hydrogen, is constantly produced.

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17. AEC Provisional Construction Permits CPPR 63 & 64, issued July 7, 1969.
20. The coolant is the liquid which passes through the core of the reactor and transfers the heat outside the enclosure so that it can do work. In civilian power reactors the coolant is almost always water, but in military (e.g., naval ships) and experimental reactors all types of coolants are used, the most common being liquid sodium.
21. Boron is always put into the water which circulates through the core to increase the density. This enables the water to absorb some of the neutron radiation
the diagram, small quantities of the coolant are continually drained from the loop to prevent excessive tritium concentration.  

The second water system is the steam system. After the water in the primary system is heated in the core, it passes into the coils of the steam generator where it heats and boils the water in the steam system. The steam passes through the turbines where it generates the electricity and then enters the condenser. There it is cooled first into water and then cooled further below the boiling point (212°F) by the passage of water from the third system over it in condensing tubes.

The third system, of course, absorbs heat while doing this. Here the ecological problem of thermal pollution enters, because the third system consists of the Chesapeake Bay and the pipes and pumps which circulate its water. The Calvert Cliffs plant will withdraw and return to the Bay 2,400,000 gallons of water every minute. This stream of hot water from the plant would create the fourth largest tributary entering the Bay, surpassed only by the Susquehanna, the Potomac and the James Rivers. This step cannot be eliminated; without condensing and cooling, the system would be highly inefficient and uneconomical.

Aside from a major accident involving a "runaway" reaction releasing large quantities of radioactive fission products into the atmosphere, the disposal of the small quantities of the primary coolant con-
taining tritium creates the greatest danger of nuclear pollution. After being drained from the primary system, the coolant enters "an elaborate waste treatment system where most of the radio-nuclides are removed, before going into large receiving tanks. Water from the tanks is piped to the discharge canal on a controlled basis" and there released into the Bay. Nothing in this system prevents the release of tritiated water since, as far as the system in concerned, tritiated water is indistinguishable from ordinary water. In the course of a year the two units at Calvert Cliffs will discharge 5800 curies of tritium into the Bay, almost 400 times as much as that of the next most common radionuclide discharged.

Power from the plant will travel to BG&E's main load centers by means of a 47-mile long corridor containing two separately supported 500 kv overhead lines. The area to be traversed by the corridor includes both highly developed suburban land and some sites of "historical and architectural importance . . . recorded as part of the National Register of Historic Sites and Buildings."

II

BG&E'S INTERNAL DECISIONS

A. Determining the Need for Increased Capacity

All electric utilities operate under regulations which require them to provide all the power needed for consumption in their service areas. To meet this requirement, utility companies must plan for their needs seven to ten years in advance, which is the time allowance necessary to plan and construct new generating capacity. This requires the utili-

26. AEC Transcript, supra note 14, at 367.
27. Water is, as everyone knows, composed of two atoms of hydrogen and one of oxygen (H₂O). If one or both of the hydrogen atoms are tritium the molecule will still behave in all chemical respects exactly like ordinary water, except that it will be radioactive.
28. AEC Transcript, supra note 14, at 252. One curie is the amount of radiation emitted from 6615 pounds of natural uranium. 10 C.F.R. § 20.5(c)(2) (1967).
29. The greatest discharges into the Bay after tritium will be: Cobalt 58, 7 curies; Chromium 51, 2 curies; Manganese 56, 2 curies; and Cobalt 60, 1 curie. AEC Transcript, supra note 14, at 348, table I.
31. AEC Transcript, supra note 14, at 159.
ties to determine their peak demand ten years hence; here they encounter considerable projection difficulties.

The simplest method of estimating future demand is a simple time-basis projection.\(^{34}\) This method was used by almost all private utilities at the time that BG&E decided to build the Calvert Cliffs plant in the early 1960's;\(^{35}\) it is the one used by the Federal Power Commission for estimating nationwide demand,\(^{36}\) and it is the method still used by many utilities.\(^{37}\) In non-mathematical terms, the concept is simple to understand: one makes a chart of the growth of electrical demand in the past and projects it into the future at the same rate.

The actual figures used by the Federal Power Commission for nationwide demand illustrate the results. In 1940 the load was 29.1 million kw; in 1950, 64.3 million kw; in 1960, 138 million kw; in 1970, 277 million kw. From these figures the predictions are in 1975, 396 million kw; in 1980, 554 million kw; in 1985, 766 million kw; in 1990, 1051 million kw.\(^{38}\) The projections were reached by determining that demand had doubled every ten years up to 1970 and that, therefore, demand will continue to double for decades to come.

The problem with this method is that, in the immortal words of Mr. Goodman, "footprints cannot predict the future,"\(^ {39}\) or, in more technical terms, time is a dummy variable in the equation because there is no causal relationship between time and electrical demand. The method assumes that all of the factors responsible in the past for creating electrical demand will continue to exist in the future with unabated effect. This assumption is false for the simple reason that when every household is air conditioned and heated and has refrigerators, freezers, washers, dryers, dishwashers, garbage disposals, and three color television sets, the consumer demand for electricity will almost cease to grow.\(^ {40}\) Moreover, as more households reach this "chicken-in-every-pot" status, the rate at which consumer demand grows should decrease. The utilities have made mathematical models of this "saturation" phenomenon,\(^ {41}\) based on their consumer surveys, but have not until re-

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34. A more technical analysis of this and the other methods to be discussed herein can be found in Appendix B infra.


36. FEDERAL POWER COMM'N, ANNUAL REPORT 1969.

37. For example, Detroit Edison. Brandenburg interview, supra note 35.


40. New consumer uses will continue to appear, but are not believed to be statistically significant as additions to demand. Brandenberg interview, supra note 35; Higgins interview, supra note 33.

41. For a brief discussion of this sort of "saturation model" in more mathematical terms, see Appendix B infra.
cently included these models in their forecasting equations.\textsuperscript{42} An alternative to both time-basis projections and saturation models is known as multiple regression analysis.\textsuperscript{43} This projection method is a combination of purely mathematical analysis and common sense in order to establish statistical correlations between phenomena that the utilities can predict with some accuracy and the unknown they are trying to determine—i.e., future peak electrical demand. In the Detroit Edison service area, for example, the utility might expect a high correlation between electrical demand and both area population and yearly automobile production, since the economy of the area is so highly dependent on the automobile industry. This type of analysis, however, requires fairly complex mathematics, well-trained analysts, and a fair amount of computer time. The quasi-public utilities, including Ontario Hydro and TVA, have led the way in the use of this analysis.\textsuperscript{44}

At the time of the Calvert Cliffs decision, the less sophisticated time-basis projection method was widely used by the utilities, including BG&E. The use of this method may have led to incorrect conclusions regarding future electrical demand.\textsuperscript{45}

Once utilities make a forecast, by whatever method, they must then make an extra allowance for equipment failure. In American utilities the allowance has traditionally been set at between fifteen and twenty percent of capacity, the latter figure now being recommended by the Federal Power Commission.\textsuperscript{46} Thus, if the forecasted load is 4000 mw, one builds a generating capacity of 5000 mw. This twenty percent reserve figure has been attacked by advocates of smaller and larger projections.\textsuperscript{47} The correct reserve figure, however, should not be

\begin{itemize}
  \item[42.] MacWilliams interview, \textit{supra} note 33; Brandenberg interview, \textit{supra} note 35.
  \item[43.] A more technical explanation of multiple-regression analysis is contained in Appendix C \textit{infra}.
  \item[44.] Interview with B. Roberts, Nuclear Engineering, C. Massey, Research & Development, S. Bostick, System Development and J. Warren, System Development, Office of Power, TVA, Mar. 16, 1971 (TVA interview 2); Higgins interview, \textit{supra} note 33; Brandenberg interview, \textit{supra} note 35. A letter to the author from C.R. Williams, Electric Load Forecasting Section, BG&E, on Jan. 7, 1971, indicated that BG&E now uses the multiple-regression method for short-term forecasting and is expanding its use to long-term work.
  \item[45.] Letter from S.B. Lavine, Director of Experimental Design, Sandoz Pharmaceutical Co., Dec. 28, 1970, to the author, reproduced in full as Appendix C \textit{infra}. It must be emphasized that this does not mean that the utilities' conclusions are \textit{necessarily} incorrect, merely that there is a greater probability of error.
  \item[46.] Interview with R.B. Connelly, Special Projects, C. Durfee, Engineering Design, and H.P. Claussen, Legal Department, TVA, Mar. 15, 1971 (TVA interview 1); MacWilliams interview, \textit{supra} note 33; McCarthy interview, \textit{supra} note 33; PSC construction Opinion, \textit{supra} note 18, at 32.
  \item[47.] Interview with R.F. Beers, Jr., Professor of Radiological Science, School of Hygiene & Public Health, Johns Hopkins University, Sept. 22, 1970 (too large); MacWilliams interview, \textit{supra} note 33 (too small).
\end{itemize}
the same everywhere, but should depend on the characteristics of each system. In a system composed of a small number of large generating units a twenty percent reserve is probably too small. In such a system the simultaneous failure of two or three units, surely not an inconceivable event, might leave the system with insufficient capacity to meet its demands. This is what happened to the Consolidated Edison Company of New York during the summer of 1970. For a number of reasons, its reserve going into the summer was slightly under twenty percent. When its Indian Point Nuclear Plant was shut down for servicing, its largest single remaining unit broke down, leaving the Company unable to meet its demands.\(^48\) On the other hand, a system using a large number of small generating units might not need a twenty percent reserve because, depending on the sizes of the units, many could fail simultaneously and still leave enough of the system operating to meet its demands.\(^49\)

In this respect Ontario Hydro was far in advance of the American utilities. Each time it planned a new generating unit it recalculated the amount of reserve needed. On the basis of past experience and manufacturer's data it calculated the probability of each unit being out of service on any given day and, weighting these figures to reflect the size of the units, then determined the reserve necessary to have a 98.5% chance of meeting their maximum peak demand.\(^50\) Using this system, Ontario Hydro has always met its full demand.\(^51\) In 1969 American utilities started to use this method of calculating reserve requirements\(^52\) and more and more of them, including BG&E, are now using it, as well as regression analysis, for their load forecasting.\(^53\)

In 1966, using the simple time-basis projection and a twenty-percent reserve requirement, BG&E determined that it would need an additional 1600 mw of capacity by 1975.\(^54\) The decision to build a nuclear plant was based on studies made within the company which concluded that, despite its higher construction cost, the fuel savings on a nuclear plant would make it preferable to a fossil-fuel plant in the long

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48. N.Y. Times, July 23, 1970 at 1, col. 1. The unit which broke down, "Big Allis", had provided thirteen percent of Consolidated Edison's total capacity.

49. TVA, for example, will not build units which would account for more than four percent of the system total. TVA interview 1, supra note 46.

50. On this basis Ontario Hydro does not build units amounting to more than two percent of the system total. Higgins interview, supra note 33; Reynolds interview, supra note 33.

51. Reynolds interview, supra note 33.


53. Williams letter, supra note 44.

54. MacWilliams interview, supra note 33.
Whether this projected savings is accurate is impossible to determine. It contains far too many assumptions and variables so that it cannot be evaluated. It is true, however, that more and more utilities are reaching the same conclusions and are constructing nuclear plants for new power needs. Of the six plants TVA now has under construction, for example, five are nuclear.

**B. Choosing the Site**

Having decided the size and type of plant to build, BG&E then had to determine the site. For all utilities the most important single criterion in determining site suitability is ease of access. For a fossil-fuel plant there must be access by rail or water since these are the only economical ways to ship the bulkiest raw material, the fuel. A nuclear plant requires water access because the reactor vessels are assembled by the supplier and moved to the site in one piece; they are so large that the only feasible method of shipment is by barge. This requirement restricted BG&E to sites along the Chesapeake Bay.

The second most important consideration in selecting a power plant site is the availability of cooling water. In this respect nuclear power plants are comparatively inefficient, requiring much more cooling water than do fossil plants of the same size. The absolute minimum that must be available for a nuclear plant of 100 mw or more is between 17,500 and 22,000 gallons per minute. To use only this minimum

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55. PSC Construction Opinion, supra note 18, at 9-10.

56. The two most important assumptions are (a) that the price of nuclear fuel will increase no more than twenty-five percent during the life of the plant (PSC Construction Opinion, supra note 18, at 12); and (b) that there will be an inadequate supply, and hence a high cost, of low-sulphur coal and oil (id.). On the other side of each assumption, it can be said that (a) if nuclear plants proliferate at the present rate, there will be only enough nuclear fuel for about twenty-five years and the price will thus multiply several times (Discussion with G.L. Kane, supra note 21, Jan. 22, 1970); and (b) the coal industry expects emission control devices allowing the use of high-sulphur coal, of which the supply is virtually unlimited, to be available by 1972 (PSC Construction Opinion, supra note 18, at 18-19). Both of these latter opinions are, in turn, based on other assumptions. The nuclear fuel shortage hypothesis assumes the non-development of breeder reactors; the coal hypothesis assumes the development of emission-control technology. Estimates of fuel costs and availabilities always involve assumptions as to future levels of technology and thus are incapable of being judged correct or incorrect; they can merely be reasonable or unreasonable. The BG&E decision as to comparative costs cannot be called unreasonable.

57. TVA considered all of the problems discussed in note 56 supra in deciding to build these nuclear plants. It also considered what it regards as a shortage of coal in its area due to the anti-competitive actions of the major oil companies, who own most of the major coal producers, in withholding coal from the market. TVA interviews 1 & 2, supra notes 44 & 46.

58. MacWilliams interview, supra note 33; McCarthy interview, supra note 33; Reynolds interview, supra note 33; TVA interviews 1 & 2, supra notes 44 & 46.

59. MacWilliams interview, supra note 33; Reynolds interview, supra note 33.
quantity of water—and no more—in a nuclear plant, a water recycling process, such as using cooling towers, is necessary.\(^6\) In the BG&E situation, however, cooling towers were not even considered, because they would spray over 210 tons of salt onto surrounding land and into the air every day.\(^6\) The fact that BG&E could not utilize cooling towers increased the minimum quantity of water needed to 400,000 gallons a minute. Therefore, the combination of need for access for shipping reasons and the need for a greater quantity of cooling water narrowed the site search to bayfront property with a shoreline of between 4000 and 10,000 feet.\(^6\)

The third important factor in selecting a power plant site is the expense of interconnection with the main load center, which usually compels locating the plant as close as possible to the center. This objective frequently must be subordinated to safety factors: the Atomic Energy Commission looks with jaundiced eye upon plant construction in heavily populated areas.\(^6\)

Only after all these factors have been weighed is consideration given to land acquisition cost. The reason for this low priority is that no matter how high the land cost, it is a relatively small part of the entire plant cost. For example, the land at Calvert Cliffs cost $1,585,000, while the whole project will cost approximately $347,000,000.\(^6\) For this reason, utilities generally do not confine themselves to a maximum dollar-per-acre limit.\(^6\)

After considering these factors, BG&E decided upon the Calvert Cliffs site and purchased the initial 986 acres in 1966.\(^6\) At the time, BG&E announced the acquisition for future power plant development; that it was to be used for a nuclear plant in the very near future was not stated.\(^6\)

In December, 1966, BG&E ordered the first of the two turbine-generators, scheduled for delivery in 1972.\(^6\) In early May, 1967, a

\(^{60}\) MacWilliams interview, \textit{supra} note 33; Reynolds interview, \textit{supra} note 33.

\(^{61}\) PSC Construction Opinion, \textit{supra} note 18, at 7.

\(^{62}\) MacWilliams interview, \textit{supra} note 33.

\(^{63}\) See site criteria, 10 C.F.R. §§ 100.3 & 11 (1967). Even though the 60 miles from Calvert Cliffs to Baltimore may appear a great distance, it is not when compared with the 230 miles between Baltimore and BG&E's newest fossil plants, the Keystone and Conemaugh "mine-mouth" plants located in western Pennsylvania. MacWilliams interview, \textit{supra} note 33.

\(^{64}\) PSC Construction Opinion, \textit{supra} note 18, at 5.

\(^{65}\) MacWilliams interview, \textit{supra} note 33; Reynolds interview, \textit{supra} note 33; McCarthy interview, \textit{supra} note 33.

\(^{66}\) New York Times, Jan. 24, 1971, § 1 at 42, col. 4. BG&E purchased the remainder of the site in 1968, prior to commencement of the AEC hearings on the proposed plant. Baltimore Sun, Oct. 8, 1968.

\(^{67}\) The cost of the General Electric turbine generators was $25,000,000. Peoples' Counsel v. Public Service Comm'n, — Md. —, 270 A.2d 105, 106 (1970).
contract was signed with Combustion Engineering for the design and fabrication of the reactors and the steam supply systems.68 Only then, on May 29, 1967, did BG&E publicly announce its intention to construct a nuclear power plant at Calvert Cliffs.69 BG&E immediately began preparing the studies it would have to submit as part of the Preliminary Safety Analysis Report (PSAR) to the AEC in order to apply for a construction permit.

BG&E committed vast resources—namely research and funds for land and equipment acquisition—before it made any public announcement of Calvert Cliffs' proposed nuclear future and before any public consideration was given to the propriety or safety of the proposed plant or its location. This type of prior commitment is common in the industry, and must not be discounted when seeking to explain sometimes questionable industry or AEC decisions regarding proposed plants.

III

THE AEC PROCEEDINGS

A. The AEC Licensing Scheme

By statute no atomic facility can be constructed, operated, or modified without an AEC license.71 Before granting an operating license, the AEC requires the submission of a Final Safety Analysis Report (FSAR) which must contain, among other information, descriptions of the nuclear processes to be conducted, the expected effluent, engineering and architectural features, the site and its physical and environmental characteristics, the expected routine operating procedures, the emergency plans in the event of a radiological accident, the safety features to prevent such radiological accidents, and the procedures for final disposal of all radiological effluent.72

Since the determination of these factors requires time,73 the AEC has provided for the issuance of provisional construction permits on the basis of Preliminary Safety Analysis Reports where it determines that

there is reasonable assurance that . . . safety questions will be satisfactorily resolved . . . before the . . . date . . . [set for] com-

68. 270 A.2d at 107.
70. In late May, 1967, test borings were made; in August, 1967, seismological studies; and in December, 1967, meteorological studies were conducted. Peoples' Counsel v. Public Service Comm'n, — Md. —, 270 A.2d 105, 107 (1970); DRL Safety Evaluation, supra note 19, at apps. C-1, C-2.
72. 10 C.F.R. §§ 50.34(a)-(i) (1967).
73. McCarthy interview, supra note 33.
pletion of construction . . . [and] the proposed facility can be constructed and operated at the proposed location without undue risk to the health and safety of the public.\textsuperscript{74} Theoretically the construction permit does not constitute "Commission approval of the safety of any design",\textsuperscript{75} a complete Final Safety Analysis Report (FSAR) must be submitted and the AEC must make an ultimate finding that "the final design provides reasonable assurance that the health and safety of the public will not be endangered,"\textsuperscript{76} before a license to operate the facility will be issued.

In practice, however, in almost all cases of nuclear generating plants, conversion from construction permit to operating license has been automatic,\textsuperscript{77} a fact explained by two AEC practices. First, there are only a few basic types of single-purpose reactor systems—as distinct, for example, from breeder reactor systems. In the words of the Public Health Service, "the current generation of PWR's [Pressurized Water Reactors] and BWR's [Boiling Water Reactors] cannot be placed in the same class as prototype and test reactors"\textsuperscript{78} when considering radiological and health effects. Much experience has accumulated concerning single-purpose reactor systems; since 1958, ninety-five plants have been put on line, licensed or planned.\textsuperscript{79}

Second, at least equally important is the wording of a regulation which provides that:

Upon completion of the construction . . . in compliance with the terms and conditions of the construction permit . . . the Commission will, in the absence of good cause shown to the contrary, issue a license.\textsuperscript{80}

This regulation places the burden on a protestor to prove either that the AEC should not have issued the construction permit itself, because the plant could not safely operate as required in the permit specifications, or that the plant was not built according to the specifications in the permit. Once the AEC has approved a plant and has determined that the plant could operate without endangering the public,

\textsuperscript{74} 10 C.F.R. § 50.35(a)(4) (1967).
\textsuperscript{75} 10 C.F.R. § 50.35(b) (1967).
\textsuperscript{76} 10 C.F.R. § 50.35(c) (1967).
\textsuperscript{77} McCarthy interview, supra note 33; interview with J.C. Cawood, Jr., Esq., attorney for Chesapeake Environmental Protection Association, Inc., Dec. 23, 1970; interview with R.C. Woodbury, Esq., General Counsel, Temporary State Commission of the Environmental Impact of Major Public Utility Facilities (New York), Oct. 29, 1970; MacWilliams interview, supra note 33.
\textsuperscript{78} “Public Health Factors in Reactor Site Selection” in: “Hearings on Environmental Factors in Selecting Powerplant Sites,” Subcommittee on Air and Water Pollution, U.S. Senate, 90th Cong., 2nd Sess. 1248, 1251.
\textsuperscript{80} 10 C.F.R. § 50.56 (1967), emphasis added.
the AEC would probably not reverse itself. In fact, this has never
happened.

Whether the plant has been built in accordance with the permit is a somewhat more difficult question. During the early stages of con-
struction at Calvert Cliffs, for example, four changes were made from
the initial plans.81 The Provisional Construction Permit authorized
construction “as described in the application and the hearing record
in accordance with the principal architectural and engineering criteria set
forth therein.”82 The difficult “mixed question of law and fact” is to
determine whether or not the four changes made were of “principal
engineering criteria as set forth in the application.” A determination
that the changes were major could render the entire plant not “in com-
pliance with the terms and conditions of the construction
permit,”83 thus voiding the permit and preventing the plant’s operation. To avoid
such problems, public opposition to nuclear plants would have to be
asserted at the construction permit stage, although some intervenors at
later stages have been successful.84

B. The AEC’s Consideration of Environmental Questions

At the time the Calvert Cliffs’ construction permit application was
under consideration, the AEC construed its responsibilities on construc-
tion permits very narrowly, even on the question of public safety. The
only safety problems it considered were the safety of having construc-
tion proceed and the possibility that all safety questions could be solved
by the time construction was completed.

Judicial sanction for this narrow approach to safety grew out of
the dispute over the construction permit for Michigan’s Enrico Fermi
No. 1 reactor.85 Approval for the Fermi 1 construction permit was
considered by the U.S. Supreme Court,86 which upheld the AEC’s
view that the issuance of a construction permit could follow a finding

81. 1 BG&E, Final Safety Analysis Report, Calvert Cliffs Nuclear Power Plant,
Jan. 4, 1971, § 1.7.
82. AEC Provisional Construction Permits, supra note 17.
83. It should be noted that some changes in the original plans are almost always
made during the course of construction. TVA interview 1, supra note 46; interview
with H.C. Nickel, Nuclear Division, Allis-Chalmers, Inc., May 4, 1970; McCarthy
interview, supra note 33.
84. A recent case in which public intervention after the construction permit
stage was successful is that of the Palisades Plant of Consumers Power Co., Michigan,
in which the intervenors at the operating license stage forced the company into a
“settlement agreement,” signed March 12, 1971, which required substantial modifica-
tions to the plant’s cooling and radioactive waste systems after construction was com-
plete. AEC Docket No. 50-255.
that construction is safe and that the AEC could "defer a definitive safety finding until operation is actually licensed." This case is still the law with respect to safety and the AEC's view of the extent of the safety inquiry at the construction permit stage has not changed.

The AEC's consideration of the environmental effects of nuclear plants, like its approach to safety problems, was narrow, being strictly limited to the effects of radiation. In early 1969, just five months before the Calvert Cliffs hearings, the AEC received judicial approval of this position in State of New Hampshire v. A.E.C. The reactor under consideration there would use Connecticut River water for cooling purposes; the State of New Hampshire sought to have the AEC consider the resulting thermal effects before issuing a construction permit. When the AEC refused, New Hampshire took the case to the First Circuit, which upheld the AEC's position that, under the Atomic Energy Act, it was empowered to consider only questions of a radiological nature. The Supreme Court denied certiorari. This case has since been specifically overruled by the Water Quality Improvement Act of 1970, but this Act was too late to affect the hearings on Calvert Cliffs.

Section 102 of NEPA also enacted too late to affect the Calvert Cliffs licensing proceeding, further changes the AEC's position on environmental matters. It provides that before any Federal agency can take any action which might affect the environment it must make a public report on the proposed action. The AEC has twice amended its regulations to conform with this statutory scheme and now requires an applicant to submit an "Environmental Report." This document is to discuss all environmental impacts of and alternatives to the proposed facility; "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term pro-

87. Id. at 407.
88. See Green, Safety Determinations in Nuclear Power Licensing: A Critical View, 43 Notre Dame Law. 633 (1968), noting that AEC inspection of nuclear power facilities is by technical specialists operating beyond effective public scrutiny; Cawood interview, supra note 77; interview with H. Fischer, Esq., Fischer Sprague Franklin & Ford, Detroit, Mich., Oct. 3, 1970. Also ignored by the AEC is the danger to the public from possible enemy attack on, or sabotage of, nuclear plants. Seibel v. AEC, 400 F.2d 778 (D.C. Cir. 1968).
92. 84 Stat. 61 (1970), which states that the appropriate state, interstate or Federal water quality control authority must certify that there is "reasonable assurance . . . that the activity . . . will not violate applicable water quality standards" before a Federal license to operate or construct can be granted.
ductivity”; and “any irreversible and irretrievable commitments of resources which would be involved in the proposed action.” The regulations also state that the Environmental Report “shall be sufficiently complete to aid . . . in developing and exploring . . . appropriate alternatives [and] shall include a cost-benefit analysis” of both the proposed facility and the possible alternatives.

After the report is submitted to the AEC, copies are sent to all Federal, state, and local governmental organizations that are concerned with or affected by the proposal; the AEC invites their comments, and notice of the existence of the report is published so that other interested organizations can read the report and submit comments. Upon receipt of all comments, the Regulatory Staff prepares “a draft detailed statement of environmental considerations” which is retransmitted to the governmental agencies and made available to the public, for further comments. The Regulatory Staff then prepares

a final detailed statement . . . including a discussion of problems and objections raised . . . and the disposition thereof, . . . a final

96. 36 Fed. Reg. 18071 §§ A1(d),(e) (1971). The original version of the regulations, issued in 1970 [35 Fed. Reg. 8594], was no more specific than this one as to the content of Environmental Reports. This vagueness helped to defeat the purpose of the reports. In the BG&E “Applicant's Environmental Report” on Calvert Cliffs, for example, filed with the FSAR [see note 81 supra], the part entitled “Irreversible and Irretrievable Commitment of Resources” read, in its entirety:

Only that portion of the nuclear fuel which is burned and not recovered on reprocessing is irretrievably lost to other uses. All other resources are either left undisturbed, or committed only temporarily as during construction, or during the life of the plant, and are not irreversibly or irretrievably lost.

FSAR, supra note 81, at 64. Nothing was said about the possible loss of the striped-bass and croaker fisheries of the bay due to thermal effects, although this would certainly be an irretrievable commitment of resources. Admittedly, earlier sections of the report went into great detail to prove that fishery damage would not occur, but the possibility should still, one would think, have been mentioned in a discussion of irretrievability. Even so, however, the Calvert Cliffs report was a good deal more comprehensive than the report filed in September, 1970, by Detroit Edison for the Fermi 2 plant [AEC Docket No. 50-341] which did not even discuss the possibility of environmental damage, simply stating that such damage was impossible.

97. 10 C.F.R. § 50 App. D, §§ A 2, 3 (1971). These requirements were added in the September 1971 revision in an attempt to meet the criticisms made by the Court of Appeals for the District of Columbia Circuit in Calvert Cliffs Coordinating Committee v. AEC, — F.2d —, 2 E.R.C. 1779 (July 23, 1971). Whether they will provide greater protection for the environment is doubtful since it is almost impossible to provide any type of “cost-benefit” figures for environmental impacts, and even the Environmental Reports for the Calvert Cliffs and Fermi 2 plants filed under the older regulations, gave rather full discussions of possible alternatives. See note 96 supra.


99. Id. §§ A 6, 7.
cost-benefit analysis . . . [and] an analysis . . . of the alternatives available for reducing or avoiding adverse environmental effects, as well as the environmental, economic, technical, and other benefits of the facility.\footnote{100}

This final statement is submitted into evidence at the licensing hearing and the hearing board must "independently consider the final balance among conflicting factors" to determine "the appropriate action to be taken."\footnote{101} Any license or permit issued requires the facility to meet all applicable federal, state and local environmental standards.\footnote{102}

This procedure appears to be an excellent system but there is one potential defect which could undermine the entire structure. Even should some set of comments state the belief that the facility will be unable to conform to a given set of standards, the license can still be issued if the licensing board concludes that the facility will be environmentally sound (except in the case of water quality standards\footnote{103}), and if the licensing board, as we shall see,\footnote{104} tends to defer to the "expertise" of the regulatory staff. Once the board has heard all the arguments, it alone makes the decision, and can rule in favor of the plant even if some negative reports have been received. The decision will probably be upset only when an "abuse of discretion" is shown. Thus, the safeguards would be avoided. Until there is a case in which this problem arises, then, we can only say that there is the possibility that the new regulations will not be an effective safeguard of environmental quality.

At the time of the Calvert Cliffs construction permit hearings, of course, none of these statutes or regulations was in effect, and BG&E filed no environmental report along with the Preliminary Safety Analysis Report. The extent to which the outcome would be affected if the hearings were held today with the submission of an environmental impact study is impossible to determine. BG&E, however, will have to comply with the 1970 Water Quality Improvement Act and NEPA before an operating license can be issued.\footnote{105}

\footnote{100. Id. § A 8.}
\footnote{101. Id. § A 11 (d).}
\footnote{102. Id. § A 13. This merely means that should the facility fail to meet such standards it would be in violation of its AEC license as well as in violation of state law. Even under State of New Hampshire v. AEC, 406 F.2d 170 (1st Cir. 1969), \textit{cert. denied}, 395 U.S. 962 (1969), the states were held to be able to control such violations. See text accompanying note 89 \textit{supra}.}
\footnote{103. See note 92 \textit{supra}.}
\footnote{104. See text accompanying notes 176-85 \textit{infra}. \textit{See also} Green, \textit{supra} note 88.}
\footnote{105. Operating licenses as well as construction permits are subject to these provisions and the application therefor was not filed until January, 1971, after the effective date of the statute and regulations. A comprehensive 170-page environmental impact report was filed by BG&E with the FSAR.}
C. Pre-hearing AEC Procedure

BG&E filed its Preliminary Safety Analysis Report with the AEC on January 25, 1968, approximately eight months after the public announcement of the intention to build. In the meantime, BG&E had ordered the turbine-generator for the second unit and had hired Bechtel Corporation as the general consultant for the construction activities.

The AEC distributed the report to the Division of Reactor Licensing (DRL) and to the Advisory Committee on Reactor Safeguards (ACRS) for their examination and approval. Upon receipt of the report, the staff of the DRL in turn sent copies to the DRL's "consultants" for their comments. These consultants are mainly other government agencies having special expertise in particular areas. Almost immediately after receiving the PSAR, the DRL staff started holding conferences with BG&E representatives concerning the PSAR, on the average of once a month.

The first consultant report received came from the Air Resources Environmental Laboratory of ESSA (the Weather Bureau), and it was highly critical of the meteorological assumptions and proposals in the PSAR. On March 29, 1968, the DRL staff and BG&E met to discuss this report and, on June 28, 1968, BG&E submitted an amendment to the PSAR on this problem. This amendment, however, did not satisfy ESSA and, on September 27, 1968, a second conference between BG&E and the DRL was held, resulting in the submission of another amendment. Although this amendment was the last on the subject, ESSA, in a report to the DRL on December 23, 1968,
stated “we are still concerned” and suggested other locations for certain equipment.116

The initial comments of the Army Coastal Engineering Research Center (CERC) concerning the storm and tidal effects discussed in the PSAR similarly stated a need for additional data.117 When the data was supplied, CERC submitted a second report which stated “there is insufficient information submitted to date” to answer all of the important questions.118

In all, six consultants submitted nine reports119 and nine amendments were made to the PSAR before the hearings opened in April, 1969. Most of these amendments, however, were not in response to comments by the consultants, but were designed to alleviate deficiencies noted by the DRL staff.120

On October 4, 1968, between the filing of the PSAR and the hearing, BG&E submitted a request to the DRL for permission to engage in certain construction activities before the permit was issued. The Regulations provide for this procedure:

The Commission may, upon application, . . . grant such exemptions . . . as it determines are authorized by law and will not endanger life or property . . . and are otherwise in the public interest.121

The BG&E request involved the buildings, foundations and walls, and not the actual reactor and generator components.122 After a request for, and the receipt of, additional information, the DRL granted the exemption request on January 10, 1969.123

While the DRL was evaluating the Preliminary Safety Analysis Report, another AEC group, the Advisory Committee on Reactor Safeguards (ACRS), was also investigating the report. Established by Congress to give independent advice to the AEC, the ACRS is composed of persons knowledgeable in the field who are not AEC employees.124 The ACRS, however, lacks power to compel the AEC to

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116. Id. app. C-3.
117. Id. app. D-1.
118. Id. app. D-2.
119. See note 109 supra.
120. DRL Safety Evaluation, supra note 19, app. A.
121. 10 C.F.R. § 50.12 (1967).
122. The sections to be constructed prior to the construction permit were “the base slab and sides of tendon access galleries, the containment mud slabs, and the auxiliary building base slab, floors, and side walls up to an elevation of 27 feet.” DRL Safety Evaluation, supra note 19, app. A.
123. The DRL requested additional data on October 18, 1968; BG&E transmitted the requested information on November 18 and 27, 1968; the DRL letter granting the exemption was sent on January 10, 1969. Id.
adopt its findings and opinions.\textsuperscript{125} The Advisory Committee’s report, submitted after two meetings with BG\&E and the DRL,\textsuperscript{126} took what one commentator considers the normal ACRS form—some closely reasoned critical discussion followed by a final paragraph which “typically expresses the committee’s judgment that all outstanding issues can be resolved during construction.”\textsuperscript{127}

The Advisory Committee reviewed the PSAR as amended, and the problems mentioned in the ACRS report had apparently not been considered by either BG\&E or the Division of Reactor Licensing. Yet the ACRS assumed that the solutions to those problems could safely be left to the DRL and BG\&E, and, on that assumption, gave its approval to the construction permit. Although established for the express purpose of providing a knowledgeable, independent body to advise the DRL staff, the ACRS abdicated its responsibility to assure the public safety and welfare by assuming that the DRL or industry (BG\&E) would solve these problems by the time the \textit{fait accompli} of a constructed plant would be presented to the AEC.\textsuperscript{128}

\textsuperscript{125} Murphy, \textit{Atomic Safety Licensing Boards: An Experiment in Administrative Decision Making on Safety Questions}, 33 \textit{Law \& Contemp. Probs.} 566, 569 (1968).
\textsuperscript{126} DRL Safety Evaluation, supra note 19, at app. A.
\textsuperscript{127} Green, supra note 88, at 641. How true this description is can be seen from the last three paragraphs of the ACRS report on Calvert Cliffs, set out in full here:

The applicant has discussed his assumptions on the post-accident production of hydrogen in the containment atmosphere due to radiolysis and metal-water reactions. The Committee believes that further consideration should be given to means of coping with additional hydrogen which might be generated by Zircalloy-water reactions in the postulated loss-of-coolant accident if the effectiveness of the emergency core cooling system should be less than that predicted by the applicant. This matter should be resolved between the applicant and the AEC regulatory staff.

DRL Safety Evaluation, supra note 19, at app. B. The problem referred to here stems from the creation of hydrogen as a product of a chemical reaction between the water and the cladding. The heat in the core then ignites the hydrogen, producing a chemical (as distinguished from nuclear) explosion which could break open the reactor and release radioactive substances into the environment.

The main coolant-pump flywheels represent a potential source of missiles within the containment, and the applicant has described measures to be taken to minimize the possibility of flywheel failure. Additional steps may be warranted to insure the integrity of the flywheel assembly; the Committee recommends that details concerning adequacy of design, material characteristics, quality assurance, and in-service inspection requirements be resolved between the applicant and the AEC Regulatory Staff.

The Advisory Committee on Reactor Safeguards believes that the above items can be resolved during construction, and that, if due consideration is given to these items, as well as those previously emphasized by the Committee for all large water-cooled reactors, the nuclear plant proposed for the Calvert Cliffs site can be constructed with reasonable assurance that it can be operated without undue risk to the health and safety of the public.

\textit{Id.}

\textsuperscript{128} This criticism, of course, is applicable to the entire AEC licensing scheme whereby construction permits allow a whole plant to be built before final AEC approval of its operation. See text accompanying notes 73-84 supra.
D. The AEC's ASLB Hearings

Having disposed of these preliminaries, the AEC, on March 28, 1969, published notice of the public hearing to be held before an Atomic Safety and Licensing Board (ASLB) to consider the application for a construction permit for the Calvert Cliffs plant. The ASLB is a relatively new feature of the AEC. It consists essentially of non-government employees, like the Advisory Committee on Reactor Safeguards, but it is much smaller, having only three members. Two of these members must be technically qualified to evaluate the scientific evidence and the third, the Chairman, must be qualified to conduct administrative hearings. For the Calvert Cliffs hearings, the two technical members were Dr. Clark Williams, formerly on the staff of Brookhaven National Laboratory, then Research Administrator of the Marine Resources Council of the Nassau-Suffolk (Long Island, N.Y.) Planning Board, and Mr. Reuel C. Stratton, a registered engineer and former member of the Advisory Committee. The Chairman was Professor Arthur W. Murphy of Columbia University Law School.

1. The organized opposition.

After publication of the notice, as provided for in the regulations, two petitions for intervention were filed, one by Anne Arundel County, Maryland, and one by the Chesapeake Environmental Protection Association, Inc. (CEPA). At a prehearing conference called pursuant to the regulations, at which both prospective intervenors were represented by counsel, both petitions were granted without opposition from either BG&E or the DRL staff.

Anne Arundel County is the county immediately north of Calvert County. Its major city is the state capital, Annapolis, which is 38 miles from the site. Initially taking no position, the County intervened only for the purposes of gathering information and, if the need should subsequently appear, of participating to protect its interests. It did not intend to and, in fact, did not present any witnesses of its own.

The Chesapeake Environmental Protection Association was founded in January, 1969, for the express purpose of opposing the Calvert Cliffs project. It has a membership of between 250 and 300 fami-

129. 42 U.S.C. § 2241 (1971); Murphy, supra note 125.
130. AEC Transcript, supra note 14, at 49.
133. AEC Transcript, supra note 14, at 3. The conference was held in Washington, D.C., note 14, on April 29, 1969.
134. Id. at 15, 22.
lies, local residents in Calvert and southern Anne Arundel Counties, and is organized and incorporated as a non-profit institution. It has no full-time employees, its work being done by the more active members, most of whom are retired professionals. The organizers of CEPA felt no devotion to the ecology of the bay or the safety of the residents in the immediate vicinity of the plant. They were "annoyed by the power lines" which would cross their properties if the plant were approved. Reasoning that if there were no plant there would be no transmission lines, they organized to fight the plant using the ecology and safety arguments.\textsuperscript{138}

In all except the legal battles the leadership of the opposition was not CEPA, but the Chesapeake Bay Foundation, a separate non-profit organization with several full-time employees. Its executive director, Jess W. Malcolm, first became concerned about the Calvert Cliffs proposal in February, 1968,\textsuperscript{136} and organized a committee of scientists to study it. The scientists expressed concern about both thermal and radiological effects on the bay, and announced their opposition to the plant until its effects were fully understood.\textsuperscript{137} At this point, September, 1968, Malcolm started the organization of what is now known as Quad-C (for Calvert Cliffs Coordinating Committee), which served as the spokesman for all opposition groups\textsuperscript{138} except CEPA.\textsuperscript{139}

2. \textit{The hearings.}

At an Atomic Safety and Licensing Board hearing any person not a party to the proceeding may "be permitted to make a limited appearance by making oral or written statement of his position on the

\begin{footnotes}
\item[135] Cawood interview, \textit{supra} note 77; interview with J.W. Malcolm, Executive Director, Chesapeake Bay Foundation, Oct. 28, 1970.
\item[136] Baltimore Evening Sun, Feb. 21, 1968.
\item[137] This brought the politicians into the matter. Both Governor Agnew and Senator Tydings stated that no further construction should be done until a full, objective study was made. Baltimore Evening Sun, Mar. 28, 1968; Baltimore Sun, May 12, 1968.
\item[138] The opposition represented by Quad-C included the Sierra Club and the National Wildlife Federation.
\item[139] Quad-C and CEPA do cooperate. CEPA learned through Malcolm of Dr. Carleton Ray of the School of Hygiene and Public Health of The Johns Hopkins University, who organized the group of experts, known as the "Hopkins Seven," who testified in opposition to the plant. Cawood interview, \textit{supra} note 77; Malcolm interview, \textit{supra} note 135; interview with Dr. Carleton Ray, Associate Professor of Pathobiology, The Johns Hopkins University School of Hygiene & Public Health, Sept. 18, 1970.
\item[139] The "Hopkins Seven" included Dr. Ray; Dr. Edward P. Radford [see note 169 \textit{infra}]; Dr. Roger M. Herriot, Chairman, Dept' of Biochemistry; Dr. Cornelius W. Kruse, Professor of Environmental Medicine; Dr. Timothy Merz, Associate Professor of Radiobiology and Radiological Science; Dr. Charles Southwick, Professor of Pathobiology; and Brenda K. Sladen, Research Associate in Pathobiology.
\end{footnotes}
issues within such limits . . . as may be fixed by the presiding officer." When the hearing opened on May 12 in Prince Frederick, the County seat of Calvert County, there were eighteen such limited appearances. In explaining the Board's duties and setting the limits of the statements, Chairman Murphy restated the position examined earlier in this Article, that comments on zoning, transmission lines, power costs and thermal effects would not be relevant since the hearing would be concerned solely with radiological problems.

As might be expected, the limited appearances covered the entire spectrum of opinion. Those expressing confidence in the AEC and in the state regulatory agencies to protect the bay included the County Commissioners of Calvert County, a member of the Maryland House of Delegates, the Calvert County Board of Trade, the local economic development agency, a local banker, and a real estate developer. They therefore favored the project in light of the expected economic benefits to the area. Declaring his support for the plant, one real estate developer launched an extremely vitriolic attack on all conservationists in general and in particular former Senator Tydings.

Limited appearances in opposition to the project as described in the application and PSAR were made by the Chesapeake Bay Foundation, Potomac River Association, St. Mary's County Waterman's Association and various local civic groups. Two groups opposed the project because the transmission lines would impinge upon local registered historic sites, and two local residents spoke on their own behalves. Some opponents indicated that they might feel differently if cooling towers were used. Two leading politicians from the area took no positions in many words. Having now consumed more than half a day proving that not a person in the room except the reporter

140. 10 C.F.R. § 2.715(a) (1971).
141. See text accompanying note 86 supra.
142. AEC Transcript, supra note 14, at 50.
143. Id. at 106.
144. Id. at 108.
145. Id. at 115.
146. Id. at 118.
147. Id. at 163.
148. Id. at 121.
149. Id. at 160.
150. Id. at 150.
151. Id. at 142.
152. Id. at 155, 159.
153. Id. at 122.
154. See notes 125 & 127 supra.
155. R.W. Benner, Maryland House of Delegates, AEC Transcript, supra note 14, at 110; Congressman R.C.B. Morton, Id.
had heard Chairman Murphy's opening comments, the ASLB and the parties settled down to the serious business of the application.

Two issues which ASLB must consider before granting a permit, whether the applicant is technically\textsuperscript{156} and financially\textsuperscript{157} qualified to design and construct the proposed facility, were both conceded by CEPA—the first by omission, the second explicitly.\textsuperscript{158} The only issue that was actively contested was the safety of the proposed plant, and this was confined to the radiological discharge problem, particularly that of tritium. Such safety issues as those raised by the ACRS\textsuperscript{159} were not introduced by CEPA, primarily because it lacked experts necessary to contest them.\textsuperscript{160}

The CEPA concern and argument is outlined as follows: First, there is no threshold effect in radiation damage to biological organisms, including man; thus, any increase in radiation, no matter how small, will produce some effect.\textsuperscript{161} Second, since man is at the end of his food chain, some percentage of any tritium which is in the cells of any organism lower on the chain will eventually be ingested by people.\textsuperscript{162} Third, even though the biological half-life of tritium, that is, the time it takes for one-half of the tritiated water in an ordinary organism to leave the organism, is only twelve days,\textsuperscript{163} immature organisms which are growing rapidly will incorporate the tritium into their cells as protein, nucleic acid, or some other long-lasting compound.\textsuperscript{164} Fourth, once the tritium is bound inside the cell in such a way, the concern is not the biological half-life of tritium, but the physical half-life, 12.3 years.\textsuperscript{165} Therefore, fifth,

Subsequent organisms ingesting it as food would absorb and retain the tritium of the nucleic acids, and this isotope would be in this form if ingested by man. . . . Ultimately the concentration . . . of tritium in the more stable portions of the cells of people eating seafood

\textsuperscript{156} 10 C.F.R. § 2.104(b)(1)(ii) (1971).
\textsuperscript{157} 10 C.F.R. § 2.104(b)(1)(iii) (1971).
\textsuperscript{158} AEC Transcript, supra note 14, at 279.
\textsuperscript{159} See note 127 supra.
\textsuperscript{160} CEPA lacked the money to hire an expert and could find none willing to donate his services. In addition, CEPA's attorney, James Cawood, did not consider the problem of possible chemical explosion to be a particularly strong issue and chose not to press it. Cawood interview, supra note 77. Cf., the opinion of the Advisory Committee on Reactor Safety, supra note 127, which considered the danger of chemical explosion to be important.
\textsuperscript{161} AEC Transcript, supra note 14, at 332, 357.
\textsuperscript{162} Id. at 209, 269.
\textsuperscript{163} Kane interview, supra note 21.
\textsuperscript{164} AEC Transcript, supra note 14, at 264, 331, 359.
\textsuperscript{165} The time it takes for one half of the atoms to emit their radiation. In other words, if an organism ingested bound tritium once, and never again, it would be 12.3 years before one half of the radiation had left the organism, and another 12.3 years before one half of the remaining radiation left, and so forth.
from the Bay could be substantially higher than predicted from the water concentrations of tritium in which the organism lived. . . . The latter has been the basis of standards for waste water. 166

BG&E argued that if the average yearly concentration of tritium in the effluent did not exceed the AEC standards, then the discharge was safe. CEPA argued that what mattered was not the average, but the short-term maximum concentration, which could be incorporated in the cells of growing organisms and, thus, constitute a danger by passing up the food chain. The issue, then, was whether or not immature organisms which ingest tritium incorporate it into their body tissue—point three of the CEPA argument. 167 At the time of the Calvert Cliffs hearing, however, no experiments had been done to substantiate this point, 168 so CEPA had to prove it by forcing the BG&E witnesses to concede its accuracy.

The main characters in this drama were Dr. Morton I. Goldman, an engineer, for BG&E and Dr. Edward P. Radford, a physician, for CEPA. Both listed impressive credentials 169 and differed in their points of view, perhaps only because of having been trained in different disciplines. As environmental consultant for the applicant BG&E, Goldman testified first and stated that the waste system had been designed on the basis of highly conservative assumptions to protect the marine life of the bay, and thus to protect the people who would eat

166. AEC Transcript, supra note 14, at 335.
167. Points one, two, four and five of the CEPA argument are generally accepted radio-biological principles. Discussion with G.L. Kane, supra note 21, Mar. 10, 1971.
168. In October, 1969, some five months after the hearings, Dr. Merz, one of the "Hopkins Seven," reported that he had done some controlled experiments on the effect of tritiated water in ecological systems and had found that immature oysters did incorporate tritium into their cells. He gave these results to Senator Tydings who communicated them to the AEC. The AEC then told Dr. Merz that they knew of earlier experiments which showed the same results. Baltimore Sun, Oct. 14, 1969. The AEC also said that due to these experiments they were restudying the problem of tritium releases. Baltimore Sun, Oct. 15, 1969. Since that date nothing has been heard from the AEC concerning this study.
169. Goldman: Vice President & General Manager, Environmental Safeguards Division, NUS Corp.; B.S., Civil Engineering, NYU; M.S., Sanitary Engineering, MIT; M.S., Nuclear Engineering, MIT; D. Sc., Nuclear Engineering, MIT; U.S. Public Health Service Officer, 1950-61; Section Chief, Waste Disposal Research Activities, Oak Ridge Nat'l Lab., 1954-56; Project Leader, Waste Disposal Research Project, MIT, 1956-59. AEC Transcript, supra note 14, at 204.
Radford: Professor of Environmental Medicine, School of Hygiene & Public Health, The Johns Hopkins University; B.A., MIT; M.D., Harvard; Radiological Health Officer, USAF, 1947-49; Member Joint Task Force 7 (Eniwetok Tests); Asst Professor of Radiation Biology, Harvard, 1949-50; Researcher, Haskell Lab., E.I. DuPont, 1951-55; Assoc. Professor of Physiology, Harvard, 1955-65; Chairman, Dep't Environmental Health, Univ. of Cincinnati, 1965-68. Id. at 31.
the bay's seafood.\textsuperscript{170} Having discussed the general waste problem, he went on to comment on tritium:

The maximum tritium discharge would result in concentrations in the discharge canal averaging only 0.05 of one percent of the AEC limit for this isotope. . . . The maximum concentration in the Bay as a whole would be only two thousandths of one percent of the limit.\textsuperscript{171}

Dr. Goldman then concluded his direct testimony:

On the basis of this evaluation of the waste management system design proposed for Calvert Cliffs and the effects of its releases, I would expect to see no radiological effects in the Bay area. Further, considering the experience with waste discharges at operating power plants, the flushing action of the Bay and its tributaries, I would not expect to see any significant radiological effects now or in the future in the Chesapeake Bay water or the biota, or the people who use them.\textsuperscript{172}

On cross-examination, in an attempt to elicit an admission concerning the crucial third point of their thesis, Mr. Cawood, CEPA's attorney, and Dr. Radford questioned Dr. Goldman:

Dr. Radford. You are saying it is not necessary for the operation of this reactor to hold within . . . a certain factor of the maximum permissible concentrations over short periods of time, but if the yearly average is well below, then this is safe?

Dr. Goldman. This is the way the part 20 standards\textsuperscript{173} are written.

Dr. Radford. If the concentration shown for tritium concentration under short term maximum conditions were to be discharged in the bay it is possible that organisms in the bay would pick it up in accordance with the concentration. Is that correct?

Dr. Goldman. No sir. Tritium has never been reported to be reconcentrated\textsuperscript{174} over its concentration in the water environment.

Dr. Radford. . . . I only referred to the concentration in the water [not to reconcentration]. The word I used was "pick it up" in accordance with the concentration in the water.

Dr. Goldman. Yes, it would approach the value in the water for tritium.

Dr. Radford. If, for example, oyster larvae were swimming or be-

\textsuperscript{170} AEC Transcript, supra note 14, at 207-14.
\textsuperscript{171} Id. at 214.
\textsuperscript{172} Id. at 216.
\textsuperscript{173} 10 C.F.R. part 20 (1971) contains the AEC standards for radiation exposure.
\textsuperscript{174} Reconcentration means that more of the substance is being ingested than is being released; that it is being stored.
ing carried in this water, those oyster larvae would be growing and laying down new protein and new tissue. Wouldn't they be incorporating constituents in their body tissue?

Dr. Goldman. Yes, sir.

Dr. Radford. And what about the ratio of tritium equivalents, let's say, or the tritium ration, in the organisms that picked it up in this way?

Dr. Goldman. It would be identically the same as it is in water.

Dr. Radford. So in other words tritium would be incorporated into the body tissues of the organisms in the bay equivalent to the concentration of the tritium being released during the short term maximum. Is that correct?

Dr. Goldman. For the short period of time that condition existed, yes.

Dr. Radford. Now speaking as someone who is concerned with protecting the public, do you think it is proper to consider the exposure of the population only to the yearly average concentration and not to the short term concentration?

Dr. Goldman. Every internationally recognized body that establishes radiation standards . . . has adopted that view. I see no reason to have any other opinion.175

In his testimony Dr. Goldman came close to admitting the third point of the CEPA case. In Dr. Goldman's first and last answers, however, the rock appeared upon which the CEPA case was to founder. The fact was that the plant proposal fully complied with all emission standards. Indeed, BG&E argued, even assuming that CEPA convinced the ASLB that its fears were correct, the ASLB would still have to grant a construction permit to BG&E since the plant met the standards. As BG&E's attorney stated prior to his extremely perfunctory cross-examination of the CEPA witnesses:176

Where the [Hopkins Seven's177] statement deals with radiation effects, it appears to question the adequacy of the AEC radiation standards and not Applicant's ability to stay well below them. This hearing we feel is not the proper forum for rewriting Part 20 of the Commission's regulations. That is what rule-making procedures are for, petitions for rule-making. Part 20 is clearly within the Commission's authority, it was clearly not promulgated capriciously by the Commission, and is binding on the Board in these Proceedings.178

A similar opinion was expressed by Mr. Stratton of the Board:

175. AEC Transcript, supra note 14, at 264.
176. Id. at 366 et seq.
177. See note 139 supra.
178. AEC Transcript, supra note 14, at 365.
It would appear to this member at least that [the CEPA testimony] is a philosophical dissertation which winds up becoming a denouncement of all nuclear power plants and as such that part of the report has no place in this hearing.\(^{179}\)

This is not to say that the CEPA presentation was totally in vain. It caused Dr. Williams of the Board to ask a considerable number of questions of the technical witnesses on both sides\(^{180}\) and also elicited the following comments from him:

I am going to get in trouble because I think I am going to be able to be accused of saying that our responsibility here as a hearing board goes beyond the necessity of saying that CFR 20 is being observed. Because I wind up signing a statement that says that in my opinion the construction of this plant is not going to be a hazard to the health and safety of the population.\(^{181}\)

Chairman Murphy made no direct comment on this issue, but he was apparently unwilling to accept the BG&E argument that an ASLB could not refuse to license a plant which met the Part 20 standards. Mr. Murphy's views were reflected in the Board's decision which equivocated by stating that it was possible that the Part 20 standards might be ignored if the proof clearly showed that these limits did not sufficiently safeguard the public, but the ASLB held that no such proof had been presented at this hearing.\(^{182}\)

This leads one to wonder what the result would have been either if Dr. Goldman had actually admitted point three of the CEPA case\(^{183}\) or if experiments showing tritium incorporation by organisms had been performed earlier.\(^{184}\) Since neither of these events actually occurred, the AEC, pursuant to the opinion of the ASLB, issued the construction permits to BG&E on July 7, 1969.\(^{185}\)

\(^{179}\) Id. at 393.

\(^{180}\) Id. at 395-415.

\(^{181}\) Id. at 395.

\(^{182}\) The basic function of the Board is to make a finding that there is reasonable assurance that the proposed reactor may be constructed and operated without undue risk to the health and safety of the public. The Part 20 limits, of course, play a central role in the question of what constitutes 'undue' risk. However, it seems to the Board that there may be cases in which the evidence introduced is such as to draw into question the validity of those regulations themselves. In such a case the Board might not be able to rely upon Part 20 as establishing the outer limits of acceptable risk. In this case, however, although questions are raised as to the underlying assumptions of Part 20, there is no evidence upon which the Board could base a refusal to accept Part 20.


\(^{183}\) See text accompanying note 175 supra.

\(^{184}\) See note 168 supra.

\(^{185}\) AEC Provisional Construction Permits, supra note 17.
CONCLUSION

On the basis of this study, which is, after all, only one of the many licensing proceedings before the AEC, some tentative conclusions can be reached. Excluding those problems which are clearly outside the AEC decision-making process, such as forecasting methods, reserve capacities, and the decision to "go nuclear", many existing inadequacies of the regulatory scheme become evident.

Under the present regulatory system the ACRS serves no major function because it lacks power to enforce its criticisms, and functions simply as an advisory body whose comments are to be considered by the Division of Reactor Licensing staff. The Calvert Cliffs situation manifests this lack of enforcement power. The Advisory Committee on Reactor Safeguards found several problems that had been considered by neither the DRL nor BG&E. Instead of suggesting possible remedies, the ACRS only revealed the problems and left their solution to the parties who had not previously been aware of their existence. The ACRS served not as a "public watchdog" but as another level of technical advisor, which deceives the public into believing that the ACRS protects society's interests. To be an effective guardian, the ACRS must have substantive power to affect the results on every application. Requiring the ACRS to give or withhold its approval of every application, rather than just allowing it passively to advise the DRL, would increase the ACRS's institutional responsibility to the public.

A second problem, equally unfortunate for the public's welfare, was the AEC's official disregard for environmental questions. This situation should be partially remedied by the Court of Appeals decision in the Calvert Cliffs case. NEPA and the 1970 Water Quality Improvement Act should rectify this situation in the area of water quality, and NEPA's required environmental impact reports and the AEC regulations enacted to implement that requirement, should be useful in pressing other areas of ecological concern, if they do not prove to be merely meaningless formalities.

186. See text accompanying note 33 supra.
187. See text accompanying note 35 supra.
188. See text accompanying note 56 supra.
189. See text accompanying note 124 supra. Of the two problems, one, the possibility of free hydrogen fueling a chemical explosion, is not mentioned or treated in the relevant FSAR section. 3 FSAR, supra note 81, at § 14.6. The flywheel problem is accounted for in the FSAR by a fuller discussion of quality control and inspection procedures. Id. at vol. 1, § 1B & vol. 2 § 4.6.6.
190. See text accompanying note 89 supra.
191. See text accompanying notes 2-13 supra.
192. See text accompanying note 92 supra.
193. See text accompanying notes 93-104 supra.
A third problem is presented by a new set of AEC regulations, issued in 1970, which may prove significant. They require that designers of reactors make every effort to keep the levels of radioactive discharge from each reactor as low as practicable.\textsuperscript{194} Although it is too early to determine the effect of these requirements, it is obvious that the meaning of "practicable" constitutes the crucial issue which will probably be resolved only in a courtroom. Does it mean technologically feasible at any cost or technologically feasible at reasonable cost? If the latter, what is "reasonable" cost?\textsuperscript{195}

A fourth question, discussed above,\textsuperscript{196} is whether an Atomic Safety and Licensing Board can refuse to license a facility which, though it meets all emission standards set forth in Part 20 of the AEC regulations, nevertheless fails to guarantee relative safety. An inescapable conflict arises between the desire for orderly administrative structure and procedure and the responsibility for the public safety. Order requires that standards, once set by a panel of rule-making experts,\textsuperscript{197} be followed until changed, and that standards should not be reevaluated every time a three-member ASLB, at least one of whom is not normally technically qualified, holds a hearing on a facility license. Safety, on the other hand, requires that where convincing evidence indicates that it would be unsafe to rely solely on the standards, then the ASLB Board should be able to deny the license on grounds not covered by the standards. Since the law on this point is nonexistent, the question is really a policy decision. Safety should take precedence and an ASLB should ignore the standards where it finds that they will not ensure safety in a given case.

A fifth problem, common to almost all administrative hearings, is slowly being solved. Years of administrative decision-making demonstrated that the public interest often went unheeded in the negotia-

\textsuperscript{194} An addition to part 20, a new section 20.1(c), reads: persons engaged in activities under licenses . . . should, in addition to complying with the requirements set forth in this part, make every effort to maintain radiation exposures and releases of radioactive materials in effluents to unrestricted areas as far below the limits specified in this part as practicable. Similar additions to part 50 require that all design and operating specifications be such as to implement this. 35 Fed. Reg. 5414 (1970).

\textsuperscript{195} It should be noted that it is now technologically feasible to build reactors having no radioactive effluent. Consumers' Power Settlement Agreement, supra note 84.

\textsuperscript{196} See text accompanying note 176 supra.

\textsuperscript{197} In the past the AEC has generally adopted the standards advocated by the Federal Radiation Council. This organization has now been abolished and its functions assumed by the Environmental Protection Agency which has done nothing in this area yet. For a discussion of the role of the Federal Radiation Council and the influence upon it of two private radiation standard setting groups, see: Boffey, Radiation Standards: Are the Right People Making Decisions? SCIENCE, Feb. 26, 1971, at 780.
tions between the regulated industries and the agencies with whom they dealt on a daily basis. The current trend toward liberalization of public intervention in administrative hearings indicates greater future attention to public desires.\textsuperscript{198}

The most fundamental problem, however, is one that is almost completely hidden. Lawyers trained in the common law are taught that the adversary system is the best means of determining an issue. Reflection on this hearing, however, should indicate that the adversary method might fail to provide for the safety of people and the environment.

In the Calverts Cliffs case, the Weather Bureau,\textsuperscript{199} the Army Coastal Engineering Center,\textsuperscript{200} and the ACRS\textsuperscript{201} all found fault with the proposed plant. Yet none of these matters was raised by the Chesapeake Environmental Protection Association at the ASLB hearing because CEPA was unable to secure experts in these fields and because the attorney for CEPA felt these issues could not be won.\textsuperscript{202}

This type of tactical decision must be made whenever the adversary system is used. In making such tactical decisions, a lawyer simplifies the issues. Trial lawyers frequently ignore weak points to concentrate on strong points. The question is whether this type of thinking is apposite to a nuclear power decision, where one small design or operation error can spell disaster. In an extremely technical area such as nuclear power, however, there is the danger that simplifying the issues will result in oversimplification of the scientific problems—and an error of this type could lead to disaster.

The possibility of a disaster is a great responsibility for a non-technical person such as a lawyer to bear. This is why the Atomic Energy Act places the primary responsibility on the AEC. As we have seen, however, the AEC experts do not necessarily assure protection of the public and the environment. \textit{Qui custodiet ipsos custodes?} The lawyer who represents an intervenor in an AEC licensing hearing must be willing to assume this burden. In view of the possible consequences of a mistake, this is not easy. But until a revolutionary change in attitude or structure completely revitalizes the AEC's licensing procedures, the burden is on lawyers to intervene, to make the proceedings truly adversary, and to protect the public and the environment.

\textsuperscript{198} See text accompanying notes 131-75 supra; see generally, J. Sax, \textsc{Defending the Environment} (1970); Reich, \textit{The Law of the Planned Society}, 75 \textsc{Yale L.J.} 1227 (1966).

\textsuperscript{199} See text accompanying note 116 supra.

\textsuperscript{200} See text accompanying note 118 supra.

\textsuperscript{201} See text accompanying note 104 supra.

\textsuperscript{202} See note 160 supra.
APPENDIX A

In the form of interviews, discussions or letters, communications with the following persons proved helpful in preparing this Article: R.F. Beers, Jr., Professor of Radiological Science, Johns Hopkins University School of Hygiene & Public Health; S. Bostick, System Development Section, Office of Power, TVA; M.R. Bourn, Chamber of Commerce of Metropolitan Baltimore; L. Brandenberg, Statistics Section, Detroit Edison; J.C. Cawood, Jr., Esq., Counsel, Chesapeake Environmental Protection Association; H.P. Claussen, Esq., Legal Department, TVA; R.B. Connelly, Special Projects Section, TVA; C.C. Constantine, Executive Secretary, Maryland Public Service Commission; M. Coutant, Esq., Department of Environmental Conservation, New York; T. Downs, Esq., Assistant Attorney General of Maryland; C. Durfee, Department of Engineering Design & Construction, TVA; J.A. Durkay, Research Biochemist, National Institute of Child Health & Human Development, NIH; H. Fischer, Esq., Fischer Sprague Franklin & Ford, Esqs., Detroit, Mich.; L.T. Higgins, Load Forecasting Department, Ontario Hydro; G.L. Kane, Professor of Physics, University of Michigan; S.B. Lavine, Director Experimental Design, Sandoz Pharmaceuticals; E.F. MacNichol, Jr., Director, National Institute of Neurological Diseases and Stroke, NIH; W. MacWilliams, Jr., Manager Electrical Engineering, BG&E; J. Malcolm, Executive Director, Chesapeake Bay Foundation; C. Massey, Research & Development, Office of Power, TVA; F.T. Mayo, Director, Great Lakes Region, Federal Water Quality Administration; W. McCarthy, Director Engineering Nuclear, Detroit Edison; P.W. McKee, Director, Department of Water Resources, Maryland; C. Miles, Division of Public Information, AEC; S. Murphy, Department of Water Resources, Maryland; H.C. Nickel, Nuclear Division, Allis-Chalmers, Inc.; H.V. Nickel, Esq., LeBoeuf Lamb Leiby & McRae, Esqs, Washington, D.C.; C.H. Poindexter, Electrical Engineering Department, BG&E; J.H. Purdy, Vice-President, Management & Staff Services, BG&E; R.C. Radice, Esq., Counsel, Large Steam Turbine-Generator Division, General Electric Co.; C. Ray, Professor of Pathobiology, Johns Hopkins University School of Hygiene & Public Health; T.B. Reynolds, Generation Concept Department, Ontario Hydro; W. Rich, Esq., Assistant Attorney General of Maryland; W.L. Ridenhour, Manager, Electric System Planning, BG&E; B. Roberts, Nuclear Engineering Section, Division of Power, TVA; H. Stetina, Esq., Director, Division of Uniform State Laws & Interstate Compacts, Federal Water Quality Administration; W. E. Trieschman, Jr., Planning Division, Baltimore District, U.S. Army Corps of Engineers; J. Warren, System Development Section, Office of Power, TVA; C.R. Williams, Chief Electric Load Forecasting Section, BG&E; R. Williams, Professor of Physics, University of Michigan; R.C. Woodbury, Esq., General Counsel, Temporary State Commission on the Environmental Impact of Major Public Utility Facilities, New York.
APPENDIX B

1. Logarithmic time-dependent growth.

A graph of this type of forecasting curve can be seen in Figure A.

\[ n_t = n_0 e^{kt}, \]

where \( n_t \) is the predicted population (demand) at time \( t \), \( n_0 \) is the population (demand) at time \( t = 0 \), \( e \) is the "universal growth constant", the basis of the natural logarithms, and \( k \) is the rate of growth. In the curve shown in Figure A, for example, \( n_0 = 1 \) and \( k = \sim.07 \), which causes \( n_t \) to double in about 10 years. Equation (i) is called a deterministic model since it assumes that, in the determination of \( k \), all random and other factors have been accounted for.

In the real world, however, this assumption is not reliable and for this reason a more general form of the equation is used which divides \( k \) into two parts, \( a \) and \( b \), and adds a term to account for purely random variations:

\[ n_t = n_0 e^{a+bt} + E, \]

in which \( a \) and \( b \) are constants and \( E \) is a term which randomly oscillates about a fixed value to take account of chance happenings that might affect the result. \( E \) can be either positive or negative and is assumed to be normally distributed with zero mean and constant variance. To use equation (ii), one takes the data for past years and fits it to the curve by least squares technique to determine the values of \( a \) and \( b \), the deviations from the fit being used to determine \( E \).

2. Saturation model.

The graph of this type of model in its simplest form is shown in figure B.
In this model it is assumed that the demand will eventually approach a limit, \( n_0 + k \), which, in a deterministic model such as Figure B and (iii) \( n_t = n_0 + k(1-e^{-bt}) \), it will never reach. Inserting the random term to get the more realistic probabilistic model (iv) \( n_t = n_0 + k(1-e^{-bt}) + E \), the graph would look more like Figure C.

\[
\begin{align*}
\text{demand} & \quad n_0 + k \\
\uparrow & \\
n_t & \quad \text{time} \rightarrow \\
\end{align*}
\]

In figure C, due to the random term, \( E \), the curve might reach and exceed the limit \( n_0 + k \), as the random oscillations will become relatively large compared to the changes in the \( k(1-e^{-bt}) \) term. Equation (iv), as was equation (ii), is fitted to the historical data by the least squares method to determine \( k \), \( b \) and \( E \).

3. Linear Regression Analysis.

The basic equation for regression analysis, in probabilistic form, is:

\[
(v) \quad n_t = n_0 + a_{1t}(x_1) + a_{2t}(x_2) + \ldots + a_{nt}(x_n) + E.
\]

Each of the \( x \)'s stands for some primary variable, such as population or income, which can, it is hoped, be predicted with some accuracy at time \( t \). The symbology \( a_t(x) \) means the function \( a \) of variable \( x \) evaluated at time \( t \). These functions can be in any form and the forms of different functions can be completely distinct from each other. It is determining the forms of these functions and their interrelations that takes time, even with computers to do the work.

One first takes the factor which common sense indicates would be most significant, for example, population, and attempts to determine \( a_1(x_1) \) from the historical data. Then one takes the next most important factor and attempts to determine \( a_2(x_2) \). Now one must go back and see if the determination of \( a_2(x_2) \) has necessitated a change in \( a_1(x_1) \) in order to remain in accord with the historical data and, if so, make it. Similarly, after determining \( a_3(x_3) \) one must check for adjustments to \( a_2(x_2) \) and \( a_1(x_1) \) and so on for all of the terms. Sometimes in doing this one finds that a factor which common sense would consider important just cannot be fit and it is then discarded. After all of the functions have been determined in this way, the model is ready for use and one merely puts in the appropriate numbers and evaluates the entire expression at time \( t \) to get the prediction figure.
APPENDIX C


"As per your request I will expound (as concisely as possible) on the methodology used by Detroit Edison.

"The deficiencies in their forecasting technique will probably dominate the good features. The advantages are simply this:

"1) They have assumed an exponential growth model which was easy to ‘fit’ and thus have a very simple ‘solution’ to a sticky problem. For long-range forecasting purposes such a model might possibly yield as reasonable an estimate as any complicated regression model.

"2) If they have prior information or knowledge that all possible factors which would seriously affect the dependent variable (e.g. sales) will ‘behave’ in the same manner as they had empirically, then such a model based on time exclusively, might be reasonable especially if there is a long history of ‘natural’ growth which is uninterrupted by unnatural factors such as war, depression, etc. Obviously, the more periods of data which are available, the more refined your fitted model (fitted by least squares) can become in terms of minimizing the residuals and explaining the percent of variation in sales.

"Now to the weaknesses or disadvantages:

"1) By using only time as an independent variable (a dummy variable, since time does not really affect anything), Detroit Edison will be at a loss to explain large deviations from their forecasts. Moreover such a model assumes a never-ending spiral of growth and one has to question the ‘realism’ of such an assumption on a long-range basis. Possibly an asymptotic growth model would be more realistic, especially if the experts at D.E. had some consensus upon when a ‘leveling out’ might occur in view of market.

"Certainly there must exist a set of factors which primarily affect the sales and for which there exist comparable historical data. If one is fortunate enough to have quantitative information on these factors then one can incorporate this set of factors or any subset into a regression model. This will be a distinct improvement if the new model, fitted, has explained a very high percentage of the variation in annual sales because one can then account for severe future fluctuations in these factors and realistically assess their individual impact upon sales.

"2) By only using the exponential time model (or any time model) you haven’t explained anything and, as a result, extrapolation becomes precarious. Certainly in using such a model there is no way to ‘adjust’ for factors such as competition, shift in population, economic conditions, etc. This leaves the D.E. forecasting department in the dark as well as the management and all they can actively do is pray that all things remain the same, otherwise, if they are predicting policy upon these forecasts they are acting out of ‘ignorance’ equal to that of a crystal-ball gypsy.
“There is a great distinction between a deterministic and a probabilistic (stochastic) model and in the ‘game’ of forecasting one is always dealing with a probabilistic problem. By unrealistically assuming that there will be a doubling of sales every ten years or so you don’t need economists, statisticians, programmers, computers, market researchers, etc. to work for you. But, of course, time bears out the truth and one cannot expect to have a growth pattern already pre-determined for you because of the myriad of factors which can potentially affect the dependent variable in an almost uncountable number of ways.

“. . . In any event, there is room for considerably more sophistication to be applied in their forecasting realm, whether they use linear or non-linear models.”

It should be noted that this letter refers to the work of the Detroit Edison Company, but they have not been singled out in any way; it is merely that they were kind enough to give me copies of all of the data they use for forecasting and to discuss their techniques with me in detail, all of which information was forwarded to Mr. Lavine and he has based his letter on it. As the principal text of this paper notes, the methods used at Detroit Edison are the same as those of other utilities.
APPENDIX D

For the convenience of the reader the following list of commonly used abbreviations and terms is provided:

ACRS  Advisory Committee on Reactor Safeguards, a part of the AEC licensing process.

AEC  United States Atomic Energy Commission.

ASLB  Atomic Safety and Licensing Board, part of AEC before which public hearings are held.

BG&E  Baltimore Gas and Electric Company.

BWR  Boiling Water Reactor, a type of nuclear power reactor.

CEPA  Chesapeake Environmental Protection Association, a citizens group opposed to the Calvert Cliffs plant.

DRL  Division of Reactor Licensing, a branch of AEC which reviews reactor applications.

FSAR  Final Safety Analysis Report, a document which must be filed with AEC before an operating license is granted.

kv  Kilovolts, 1000 volts.

kw  Kilowatt, 1000 watts.

Load Area containing 60% or more of a utilities' total demand.

Center

mw  Megawatt, 1,000,000 watts.

MWT  Megawatts Thermal, a heat rating of reactor size.

NEPA  National Environmental Policy Act of 1969

PSAR  Preliminary Safety Analysis Report, an early version of FSAR, almost always filed initially in AEC proceedings.

PWR  Pressurized Water Reactor, a type of nuclear power reactor.

Quad-C  Calvert Cliffs Coordinating Committee, a group of organizations opposed to the Calvert Cliffs plant.

TVA  Tennessee Valley Authority.
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