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STUDENT PROJECTS ON COASTAL ZONE AND OFFSHORE RESOURCES MANAGEMENT

from
Subject 13.719 "Special Projects in Coastal Management"

Associate Professor J.W. Devanney III
Visiting Lecturer R.C. Blumburg

Massachusetts Institute of Technology

Cambridge, Massachusetts 02139

Report No. MITSG 72-13
June 30, 1972

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Administrative Statement

In the coastal zone, the engineer and the state authority could work productively together. To try to mix technical types with state employees working on problems of coastal zone and offshore resources management, Professor John W. Devanney, III, Department of Ocean Engineering, and Robert C. Blumberg, Massachusetts Department of Natural Resources and Visiting Lecturer, Department of Ocean Engineering, supervised an experimental education and research project during the spring term, 1972. During the academic course, interested students studied several specific coastal zone problems, overall resolution to which lay partly within the political sphere and process.

The written results of this technical/political mixing attempt are this report, with two papers--one on aspects of the power plant environmental problem, the other on some experiments in biological data gathering and analysis involving the Woods Hole, Massachusetts sewer outfall--and a companion technical report (MITSG72-14) "A Preliminary Feasibility Study of Irish Moss Harvesting Systems." We consider these technical reports to be useful in themselves despite the less successful educational experiment that produced them.

The MIT Sea Grant Program, with the authors, has organized the printing and distribution of these project reports. Funds to do this came in part from a Henry L. and Grace Doherty Charitable Foundation, Inc. grant to MIT Sea Grant, as well as from the National Sea Grant Program, grant number 2-35150, and from the Massachusetts Institute of Technology.

Alfred A. H. Keil
Director

June 1972

CONTENTS

FORWARD

The enclosed documents, together with Report MITSG 72-14, constitute the output of the experimental program in Coastal Zone Management under the supervision of Dr. Robert Blumberg of the Massachusetts Department of Natural Resources and myself. Since this was an experimental program, some comments on the research and the educational effectiveness of the program are in order.

Statement by Professor Devanney

The output itself ranges from a solidly professional technical report on Irish Moss to an interesting and seminal but incomplete effort on power plant siting. The Irish Moss study is, I believe, a definitive investigation of this industry. The student involved became extremely interested in the area, aggressively interviewed industry sources, dived and raked for moss, and put together a coherent, comprehensive, and balanced survey which effectively addressed the question that the Department of Natural Resources was asking: what is the potential of mechanical harvesting? He also spent some time in the machine shops with several undergraduates, devising building and testing the manual moss cutter.

The Woods Hole outfall study was essentially an experimental effort by three students with biolgocial backgrounds involving diver-operated sampling and hundreds of hours of species sorting and counting. These experiments undoubtedly were worthwhile and have added to our general fund of knowledge concerning marine sewage discharge. However, the students felt uncomfortable with and shied away from the political and economic issues involved.

Both of the above efforts were characterized by little contact with the political bodies in control of the coastal zone after the initial introduction to the problem. So neither of these efforts was really successful in bridging the gap between the engineer/scientist and the political process.

The third effort, on Brayton Point power plant siting, was more successful in this vein. The student involved was an unusually self-confident and aggressive person who arranged, mainly by himself, interviews with some forty key people involved in power plant siting in New England. In so doing, he probably obtained a unique set of insights into the attitudes of these people and the functioning of the siting process. However, the timing involved did not really give him time to think through his impressions, and thus his final report doesn't really hang together. It would have been better if we had been less ambitious and directed him to merely summarize the results of his interviews. This student is now completely committed to coastal zone management problems and will probably continue the present line of inquiry through the doctoral level.

Two other efforts were undertaken under the auspices of the program. One was an aborted study of the process through which the Massachusetts Wetlands laws are being enforced and their effect on coastal zone management in which the student, whose background was solely engineering, was unable to ever get things sorted out and underway. This person's introduction to the political process was a negative one and it is doubtful if he will ever leave the confines of engineering again.

During the January Independent Activities Period a program in marine sewage treatment and discharge was offered. This program attracted some six students, three of whom produced an interim report on the physical properties of sewage plumes as a function of treatment severity. Research on this issue thus initiated is being continued by one student who intends to pursue it through the doctoral level.

Overall, in terms of the program's original goals, the intermeshing of technical types with the coastal zone political process, the program must be rated a failure. With the exception of the power plant study, the reaction was more like a ball hitting a hard surface and immediately bouncing back, bouncing in a different direction, perhaps, but essentially unchanged by the contact.

An important problem in this area was that the students were placed in the position of an expert searching for a problem in areas where no problem was perceived by the bureaucrats operating the political process. For example, with respect to Wetlands management, the bureaucrats perceived the problem as one of enforcing the present law as strongly as the courts allowed; the student was interested in the question of whether the present law was consistent with society's desires. An outsider, who essentially uninvited comes in and questions the established ground rules under which an organization has been operating, is not likely to find that organization very receptive for very long. Thanks to the strong intervention of Dr. Blumberg, we were usually able to smooth over such problems, but the students felt the tension between themselves and the people they thought they were trying to help and generally retreated to issues they could analyze independently of the political process.

The power plant siting example shows that this problem can be overcome if the student is sufficiently motivated. Better orientation prior to the actual meeting between student and public official would probably help. In any event, the program did not catch fire and we cannot recommend its continuation in its present form.

J. W. Devanney

Statement by Dr. Blumberg

My input to the program essentially was one of providing an entry into the arena in which resource decisions are made and to provide the students an "inside" look at this process. In this regard I dealt only with the studies involving Irish Moss, Brayton Point, the Woods Hole outfall and Massachusetts wetlands laws. Therefore, my comments will be confined to these projects.

I see the Irish Moss study as an unqualified success. The assessment of the mechanical harvesting potential was indeed a tremendous contribution to a real problem presently being faced by the aquacultural community. By nature, the subject dealt with the scientific or technical in nature and although the student recognized the larger political problem, i.e. Massachusetts marine fisheries statutes stifle the development of Irish Moss and other types of aquaculture, his time constraints and inclinations led him away from this issue.

The Woods Hole outfall study also tended toward the scientific side of the spectrum. My discussions with the students highlighted several distinct economic and political issues involving treatment plant outfall siting and construction, and suggested several methods of approaching these issues. Again, however, the students felt that time constraints would not allow dealing with a wide variety of problems and opted for work most closely associated with their scientific backgrounds.

Study of Massachusetts wetlands laws was very disappointing. The student was extremely bright and perceptive and through three interviews which I arranged and participated in, he quickly identified all the political and economic issues that needed coverage. Further, his engineering background did not seem to be a hindrance in any way. Unfortunately, the student developed personal problems, lost interest in the project and failed to write a final paper despite several attempts to encourage him to continue. Not withstanding this failure, I felt the student was having no difficulty penetrating, understanding or dealing with the political processes and that his initial introduction to it was a positive one.

Finally, I felt the Brayton Point Power Plant study was quite successful. Although the final report has some deficiencies

I was able to assist the student to penetrate and analyze a very sensitive political issue presently being faced by the Department of Natural Resources. In this sense, the project met even the narrow goal of the program. Further, this was the only student who took full advantage of the services and guidance I provided. This, I felt, was due to the fact that he had an economic and political science background and was himself motivated to address these issues. I feel that his interest and commitment to further pursue coastal zone problems made the program successful in itself.

In summary, none of the projects produced any impact on the coastal zone political process and in terms of this specific goal, the program failed. In part, this might be due to the fact that the students with scientific backgrounds opted for work of a scientific or technical nature; in part, due to my reluctance to push the students toward the political and economic facets of their chosen projects and in part to a time limitation which did not permit them to address both.

Parenthetically, even if the students had utilized the relatively open access to the decision makers, the direct impact of such projects on essentially political decisions is questionable. However, all the projects did address real world resource problems. The Woods Hole outfall study and particularly the Irish Moss Project made significant scientific contributions. The Brayton Point Project did penetrate the political process and produced an individual commited, at least in the short term, to coastal zone management. In this larger sense the program made a significant contribution.

Dr. Robert C. Blumberg

ENVIRONMENTAL COST-BENEFIT ANALYSIS, REGULATORY ADMINISTRATION, AND THE FINANCIAL ADMINISTRATION OF ELECTRIC UTILITIES

Steven Resnick

PREFACE

The following paper--"A Managerial and Economic View of the Power Plant Environmental Probelm"--is my research project report for the Sea Grant Program.

Because of the interview methodology on which the bulk of this paper rests and because of the relative absence of literature in some aspects of the fields investigated here, the paper has a greater than average explicit subjectiveness. I hope that the reader will view this statement as a methodological explanation and not as an apology. There may be errors in the statements attributed to the interviewees; I did not employ a tape recorder because I thought that accuracy of report would have a substantial tradeoff with the value of information proferred. If there are errors, I hope that the interviewees will notify me of them for correction in my final paper.

Finally I especially want to thank: Professor John Devanney, my project supervisor, for the freedom I have enjoyed in pursuing this research and for his perspicacious comments when called upon for assistance; Robert Blumberg, Director of Mineral Resources for the State of Massachusetts, who provided important initial entrees; the New England Electric System, which provided me with many hours of the valuable time of high personnel; Michael Telson of M.I.T., who provided valuable criticism in a field he is highly knowledgeable in; Professor Ruina and Rathgens of M.I.T., whose course

"Public Assessment of Technology" helped me to integrate my knowledge and valuably contributed to the section on social analysis; Professor Daniel Holland, the thesis advisor, with whom it is always a pleasure to discourse; and the many agency and technical interviewees who were kind enough to give me their time and opinions. (A complete list is furnished in the bibliography.)

CHAPTER I

INTRODUCTION

Ten months ago I was asked by Professor Devanney of the Department of Ocean Engineering (M.I.T.) and Mr. Blumberg, Director of Mineral Resources for the State of Massachusetts, to examine three current problems involving coastline management. I spoke with the state officials directly involved. The first problem dealt with sewage disposal, and it seemed to me that decisions were being made without a proper examination of alternative technologies and alternative costs. The second problem dealt with wetlands preservation, and it seemed to me that there were no objectives or criteria governing the disposal of the wetlands in the sense of exploitation of potential benefits or benefit-cost analysis for the state of alternative policies. The third problem dealt with the licensing of a power plant, and it seemed to me that it was inefficient for the licensing to be based on arbitrarily-based biological and chemical criteria rather than taking cost-environmental trade-offs into account in siting. I chose to do a project on this third problem.

Originally, I "merely" expected to establish cost curves for the meeting of alternative criteria for water pollution control (and most specifically, of thermal effluent). I soon learned that there was insufficient advancement of the art on which I could base quantitative figures. I also learned that there were far more important and interesting issues at stake. (Note that I had my own interpretation of the issues. The involved officials had different, more immediate views concerning their problems.)

Just what are these interesting issues? Briefly:

1) managerial coordination of decision-making among the regulatory agencies and between them and the electric utility industry and the affected locale.

2) formulation of a benefit-cost analysis which would lend itself as a tool for ameliorating the first problem and which seeks to clarify the social cost of environmental regulatory activity in terms of industrial impact and national efficiency, and which examines income transfer. Perspective is gained through an analysis of electric utility planning and operations.

3) the structuring of the first two issues into a potential framework for the management of energy strategies.

It will be noted that these problems are by no means confined to the environmental field, and it is my hope to eventually explore their significance in other areas of regulation and inter-agency decision-making to establish greater perspective for this analysis.

In consideration of the enormous range of professional knowns and unknowns and in consideration of my having only a layman's background in the subjects I was undertaking to study, I adopted a research policy of interviewing a wide spectrum of interests and viewpoints, interspersed with the reading of some technical literature and journals. In interviewing about 30 environmental agency managers, utility consultants, utility managers, technical experts, lawyers, and one housewife, the average length of each interview was about 2-1/2 hours. I enjoyed the enormously interesting experience of gaining a measure of the insights of over 200 years of professional work. I have tried to weave these insights and develop my theme into a lucid pattern of organization and resources.

In the undertaking of an approach--not the solution--to the three forementioned issues, I have had to deal with several serious limitations. One is the gaping holes in my knowledge of the material presented. The intake of insights is not equivalent to a broad detailed knowledge of a subject. On the other hand, if I did enjoy mastery of a particular field, it would have been more difficult to sympathetically treat all viewpoints. Not only would my paper have been biased toward the attitudes of my field, but also my interviews would probably have elicited less useful information. Although I have a poor opinion of broad "studies" which say nothing, I feel that a broad approach is necessary in this kind of subject and I feel I have said something useful.

Another serious limitation was the question of where to draw the line on depth and scope of treatment of what I did know. There are 93 energy studies. Should I do a 94th? In a complex area like this it would be very easy to become bogged down in description and descriptive quotes from greater authorities than myself and wind up with the conclusion that the problem is not enough money or too little modeling or too short-sighted a world. Also, in a complex area like this one, long works from persons short on reputation tend to go unread. I have written a lengthy paper, though it is very short relative to the subject.

The third serious limitation which acted to constrain and direct the effort of this paper was my personal orientation toward management strategies rather than fancy modeling or ideological education. My efforts have been directed toward setting up a public management system which accepts most of the constraints of current values and political organizations.

As a consequence of these three limitations I have decided to look at the power plant-environment-energy picture in terms of deriving better game functions for the utility industry and for society. The modeling employed here is based on a generic relationship between industry and governmental regulation. I seek to superimpose a regulatory network on the utility business and on the structure of energy-environmental interests and problems in which the behavior of each unit can be reasonably self-directed according to inherent motivation.

I recognize that there are other ways in which to view the problem and fashion its resolution. It could be viewed as a political process, as a psychological process, or as an educational process. Perhaps it is a stage in Marxian history or a manifestation of a social death wish? What I have done is to take well-known management techniques and apply them to a conceptual structure of the set of problems. I have done this despite one eminent professor declaring that there was no problem because there were enough competent decision-making institutions and another one declaring that the problem was too complex to do anything with. We will explore these statements in chapters II, IV, V, and VI.

CHAPTER II

AN OVERVIEW OF THE POSITION OF POWER PLANTS IN THE NATIONAL ECONOMY AND ENVIRONMENTAL POSTURE

During the last 50 years the U.S. average annual rate of growth of electric energy production has been about 7%. This rate of increase--a doubling every 10 years--is expected to continue for the next 3 decades. While part of this growth is due to the relationship between GNP and energy needs,* much of it is due to increased substitution of electricity for raw primary energy. In 1970 25% of total U.S. primary energy consumption was devoted to the production of electricity (up from 8% in 1920). A Federal Power Commission projection for 1990 is 50%. Current primary energy sources for electricity are coal, oil, natural gas, nuclear fuel, and hydro.

This enormous growth of the conversion (and exploitation) of primary energy to electricity has been due to the fact that electricity is an efficient use of primary energy, especially with respect to distribution. According to regression analysis, one-fifth of this growth can be "explained" by population increase and four-fifths by changes in output mix and industrial input-output relationships.** In 1970 the ultimate

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*The periods 1880-1920 and 1965-1970 respectively saw average annual energy: GNP increases of 5.6:3.4 and 5.0:3.2. Resources for the Future, Inc., Energy Research Needs - Report to the National Science Foundation, M.I.T. Environment Laboratory, 1971.

**Ibid.

consumers of electricity were household and commercial (34.3%), transportation (24.0%), and industry (41.5%).* The first sector has shown small but steady gains in the last 20 years. The demand for electricity is probably extremely stable in the short run (some hold an opposite view, though). There was no retardation in the use of electricity during the recessions of 1954 and 1958. There seems to be a low price elasticity except for space heating.**

To meet projected demands for electricity during the next 20 years, $300 billion in current dollars will be invested in the current stock and perhaps 500 new power plants of all different kinds.*** The entire electric utility industry accounts for over 8% of U.S. private investment. Most of the large new plants will be nuclear. By the year 2000 it is projected by the FPC that half of all capacity will be nuclear and half fossil fuel and hydro. At the present time there is a view that nuclear plants are more economically efficient for providing firm or base load, primarily because of the savings in fuel costs. Fossil fuel and hydro plants will be used primarily for peaking and reserve capacity. The percentage of firm load required for a "safe" level of reserve capacity for maintenance and forced outage has been increasing with the increasing complexity of construction and repair

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*Ibid.

**Ibid. and Mr. Ogden Lawyen, vice-president, New England Electric System.

***Ibid.

of generators. It is now estimated by power engineers at 20-25%. Some say this level is artificially high. Further comment is reserved until later.

Numerous problems of environmental impact are posed by power plants. Fossil fuel plants have air emissions which require plant design and fuel modifications to meet environmental standards. Nuclear plants require radioactivity safety devices with respect to background radiation, leakage, and emergency core cooling. Both kinds of plants have numerous problems relating to the use of the coolant water (at the present there are no commercial gas-cooled reactors) without which the generators could not function.

Specific water pollution problems are:

1) Release of biocides in the coolant outflow which were used to clean the condenser and discharge of other chemicals (e.g., heavy metals).

2) Thermal effluent (the average increase in temperature of coolant water through the condenser is 20°; an efficient fossil fuel plant loses 45% of its heat energy into the coolant water and 15% into the air; an efficient nuclear plant currently loses 70% of its heat energy into the coolant; the ideal efficiencies [maximum potential] of fossil fuel and nuclear are respectively 68% and 53%) which:

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*Harleman, Donald R. F., "Engineering Aspects of Heat Disposal from Power Generation," Ralph M. Parsons Laboratory for Water Resources and Hydroponics, Massachusetts Institute of Tehcnology, May, 1971.

a) Can increase temperatures to lethal limits for aquatic life by (i) decreasing the oxygen concentration in area of outflow because heated water cannot contain as much gas as cold water and because a temperature increase encourages the growth of oxygen-competing algae, (ii) increases the metabolic rate of fish beyond the existing oxygen and food life support levels, (iii) coupling with other environmental conditions, which combination of effects is lethal.

b) Interferes with sensitive stages in the life cycle of aquatic species, e.g., spawning.

c) Encourages the growth of odor-producing actinomycetes (bacteria).

The effects of thermal effluent on a whole ecology cannot at this time be firmly evaluated or predicted. It is readily observable that thermal effluent can also extend the fishing season into winter, shorten the maturation period of fish (through the effect on the metabolic rate), and reduce winter ice cover, thereby increasing oxygen concentration. It is also true that a temporary shut-off of thermal effluent can result in lethal temperature change shock to aquatic life. Different species have different levels of tolerance to temperature levels and change rates.

Cooling towers and cooling ponds instead of the "once-through" method are increasingly being used to control thermal effluent to meet legal standards as administered by the environmental agencies. Currently over 16% of 500+ mw new power plants use cooling towers and over 8% use cooling ponds.* Nearly all cooling towers (especially the larger ones) are wet-cooled. This tactic of dealing with waste heat presents problems of evaporation and drift; 10 mgd (million gallons per day) make-up water is needed for a 1,000 mw plant. Dry cooling towers use recycled water and hence do not have water loss problems; however, a large dry cooling tower presents problems of heat concentration which could seriously interfere with local weather conditions. Also, dry cooling towers are extremely expensive (15% extra capital cost versus a maximum 2% extra capital cost for a wet cooling tower); operating costs are also higher.**

Cooling towers are hundreds of feet tall and wide, and thus an additional problem of aesthetics is introduced.

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*Resources for the Future, Inc., op. cit.

**Ibid.

Cooling ponds have large make-up water requirements because of evaporation. Depending on the local weather conditions, about one acre is required,* although the use of aeration spray modules can decrease this requirement to a fraction of an acre. The primary problem of cooling ponds is availability and cost of land.

Both wet cooling towers and cooling ponds can create fogging problems.

Current FPC projections on cooling towers and ponds are that by 1990, 140-300 new stations will require cooling towers and 50-130 new stations will require cooling ponds.**

In New England power companies generally attempt to use river or ocean sites for locating plants in order to avoid extra cooling system costs. Additionally, waterway access is necessary for barge transportation of the enormous generator equipment and for fuel. These plants use once-through cooling, which requires half a million to a million gallons/day. Wet cooling towers on ocean sites pose the problem of tons/day of salt being deposited downwind. Once-through cooling, however, is a variable system. Different discharge designs are possible which affect different levels, areas and volumes of the

*Ibid.

**Ibid.

water body. Some designs meet legal standards well but hurt the environment more. An example of this case is the control of thermal effluent by restricting a given area's allowable surface temperature increase (concept of mixing zone). Such a design can also result in the largest sub-surface temperature effect, and if most of the aquatic life inhabits that level, the most environmental damage.

3) Entrainment of aquatic life in coolant intake - the intake of hundreds of millions of gallons of water per day involves a threat to neighboring aquatic life. Technology is currently sufficiently advanced for constructing screens to prevent entrainment of adult fish, but plankton (fish food), eggs and larvae cannot as yet be saved.

Although power plants occupy the tiniest fraction of the land area of the U.S., they currently require 90 bgd (billion gallons per day) of coolant water. The FPC projects a requirement of 470 bgd by 1990 - over 1/3 of the nation's average stream flow will be running through power plants if the current coolant system distribution were to remain fixed! While increased coastal (or even off-shore) location can relieve this problem, there is a system-based technical ceiling on the fraction of output that can be generated on the edge of an area-wide system.* In addition, coastal location is

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*Source: Michael Telson, M.I.T.

subject to the demands of many competing interests. The connection between economics and environmental concern stands out clearly when it is recognized that alternate rate structures (i.e., usage and capacity demand) and alternative systems of plant design are possible, each having a different economic and environmental impact (e.g., fossil fuel plants create less thermal effluent and have no radioactivity problems, but nuclear plants are cheaper to operate and have no air pollution.) This section demonstrates that power plant growth and regulation presents significant and complex problems of economic and environmental impact - too significant to be left out of explicit national policy. This author gathered the impression from interviews that power plants account for perhaps 20% of the volume of work of the environmental regulatory agencies. Such work is currently fraught with confusion as to standards and the role of ideology. This confusion has resulted in an inequitable treatment of both utilities and utilities' residential neighbors. The legal system has given some direction to this confusion which implies hopes of a resolution. It has also overloaded the current problem-solving capabilities of both the regulatory system and the private energy-utility system by shoving a great many immediate responsibilities into their laps. While these responsibilities should be implemented in their operations, no system can accept too much innovation at one time without breaking down. Innovation presents problems of sheer organization and coordination. Either a go-slow approach or a new system is required. Thus the situation of a ban on operations of new nuclear power plants and on new offshore oil drilling (fuel for fossil plants) in the Gulf of Mexico arose simultaneously. Tremendous amounts of money--increased electric bills--were spent on the large-scale installment of embrionically developed air pollution equipment. Government environmental and licensing regulatory units, accustomed to the governmental mechanism of modernization known as the unilateral and endless revision of operationally unclear guidelines of every new administration, secretary, deputy, and director, issued continuously revised guidelines with arbitrary criteria which were to have an impact of billions of dollars in an industry accustomed to an engineering sense of order and efficiency.

CHAPTER III

A QUICK VIEW OF ENVIRONMENTAL REGULATORY HISTORY AND NORMATIVE BEHAVIOR OF THE REGULATORY AGENCIES AND THE ELECTRIC UTILITY COMPANIES

The late sixties witnessed America developing an increasing awareness that resources are scarce and that the quality of life is determined in part by the public goods provided by the environment, which goods are poorly allocated (by definition as public goods) by the market. This awareness was manifested in a spate of federal and state investigative commissions and legislative enactments. The courts also played an important role in environmental protection.

Generally, these actions were attempts at organizing intra-state environmental authority under the state aegis and establishing relevant federal agency jurisdiction to provide national regulatory and research authority. Many actions were attempts to give new powers to old agencies; others were designed to construct new agencies. An early emphasis was placed on estuaries, e.g., the National Estuarine Protection Act (1968), probably because of a readily available economic argument on the importance of estuaries in the American fish catch. In the House the Committees of Public Works, Interior, and Merchant Marine and Fisheries each proposed environmental bills based on their respective jurisdictions.

The principal pieces of new legislation to come out of this churning were the National Environmental Protection Act (1969) and the Water Quality Improvement Act (1970). The former required the preparation of environmental impact statements by industry and their study by appropriate supervising federal agencies in order to protect and restore the condition of the environment. The latter charged the Atomic Energy Commission to require water discharge applicants to get prior state certification. The principal rebirth of an old power was the activation of the Refuse Act of 1899 which required the licensing by the Army Corps of Engineers of any discharge into navigable waterways.

Court decisions helped to direct the intensity and flow of the environmental issue. The licensing by the Federal Power Commission of a hydroelectric plant on High Sheep Mountain on the Snake River was successfully appealed in 1966 by the Department of the Interior on the grounds of the potential danger to fish and the power company's non-consideration of alternate locations. Another now classic court battle over electricity versus environmental impact was that of Storm King Mountain in New York. The licensing decision of the Federal Power Commission was fought by a confederation of private and local government interests on the grounds of its non-consideration of negative effects on environmental, historical, and recreational resources. The more recent Calvert Cliffs decision required the Atomic Energy Commission to use cost-benefit analysis which included the environment in its permit decisions. Not so gradually, a body of legal precedent arose which required power plant licensing agencies to require stringent analysis of environmental impact.

The licensing of nuclear standards for power plants is solely regulated by the Atomic Energy Commission. A construction permit and three levels of operating permits are required. Although nuclear power accounts for only a few percent of current capacity, it is expected to account for half of total capacity by the year 2000. Thus the AEC will play a major role in the determination of the U.S. power supply. The AEC also controls nuclear research, and thus it is charged that its licensing function has assumed an advocacy role. The Calvert Cliffs decision and the retirement of long-time chairman Glenn Seabourg have given a new direction of environmental responsibility to the AEC, although it was felt by some environmental agency directors this author interviewedthat it is still insensitive to unofficial contacts with environmental agencies. The AEC's Congressional liaison is unusual in that it is a joint committee (Joint Committee on Atomic Energy).

Regulation of interstate electricity rates and transmission lines and the licensing of hydroelectric plants is controlled by the Federal Power Commission. This agency has often been accused of serving client interests in both functions; however, utility managers interviewd by this author have insisted that they do have to prepare lengthy documentation to obtain rate increases.

Fossil fuel plants are unregulated at the federal level except that a discharge (of hot water and chemicals) requires a permit from the Army Corps of Engineers. The Corps relies heavily on the advice of the federal Environmental Protection Agency in its discharge permit decisions. Other agencies, e.g., the federal Bureau of Sport Fisheries and Wildlife (Department of the Interior), are also consulted.

Air pollution standards are currently vague and unenforced by the federal government; however, the Environmental Protection Agency intends to implement them in the near future. Other national decision-makers who have an indirect impact on power plant development (through regulations concerning fuel, etc.) are the Bureau of Land Reclamation, the Office of Coal Research (Department of the Interior), the Office of Mine Safety (Department of the Interior), the Office of Emergency Preparedness (regulates oil quotas), the private National Petroleum Council, etc.

In 1968 only 20 states had public licensing agencies for power plants.* Today, all states have a slew of such agencies regulating all aspects of power plant design from water discharge to interference with air traffic. Texas requires over 100 permits for construction and operation. The Commonwealth of Massachusetts requires permits regarding coastal alteration for power plant construction (or any other coastal project)

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*Grad, Frank P. Environmental Law, chapter 11 (Matthew Bender, 1971).

from the Public Works Department and the Divisions of Water Pollution Control and Marine Fisheries in the Department of Natural Resources.

The normative process of power system design is the performance of a sensitivity analysis of alternative system designs among a set (usually, an inventory) of sites. A system design includes old plants and proposed ones over the coming 20 or 30 years. Basic assumptions to this design are satisfaction of projected capacity demand with a given reliability index (usually a 1:10,000 loss of load probability index which means one day of system failure is expected in ten years of operation). Financing of the system--the business end--plays a purely supportive role. Design is most sensitive to the parameters of fuel, transmission, foundation, cooling system, and land cost (as an opportunity cost if already owned; includes property tax). The required plants are then allocated among the sites. The set of sites examined is not particularly large. Perhaps four or five per plant within the area of a state might be superficially examined and an in-depth cost analysis performed on two or three. Recently the cost analysis might be heavily discounted in favor of the political environment surrounding site alternatives - where can a plant be constructed with the least political opposition? Note the potential loss of efficiency in both economics and environmental quality of this kind of site decision mechanism which the current state of the social-private system's management has resulted in.

The implications of this kind of planning are that the system as seen by its designers is extraordinarily complex and expensive and therefore should not be tampered with by outsiders. A strong professional sentiment lies at the heart of any power system design.

CHAPTER IV

BRAYTON POINT - A CASE HISTORY

The following case history of Brayton Point was culled from two rounds of interviews with most of the involved environmental agencies, the utility company, and the legal counsel of the interveners.

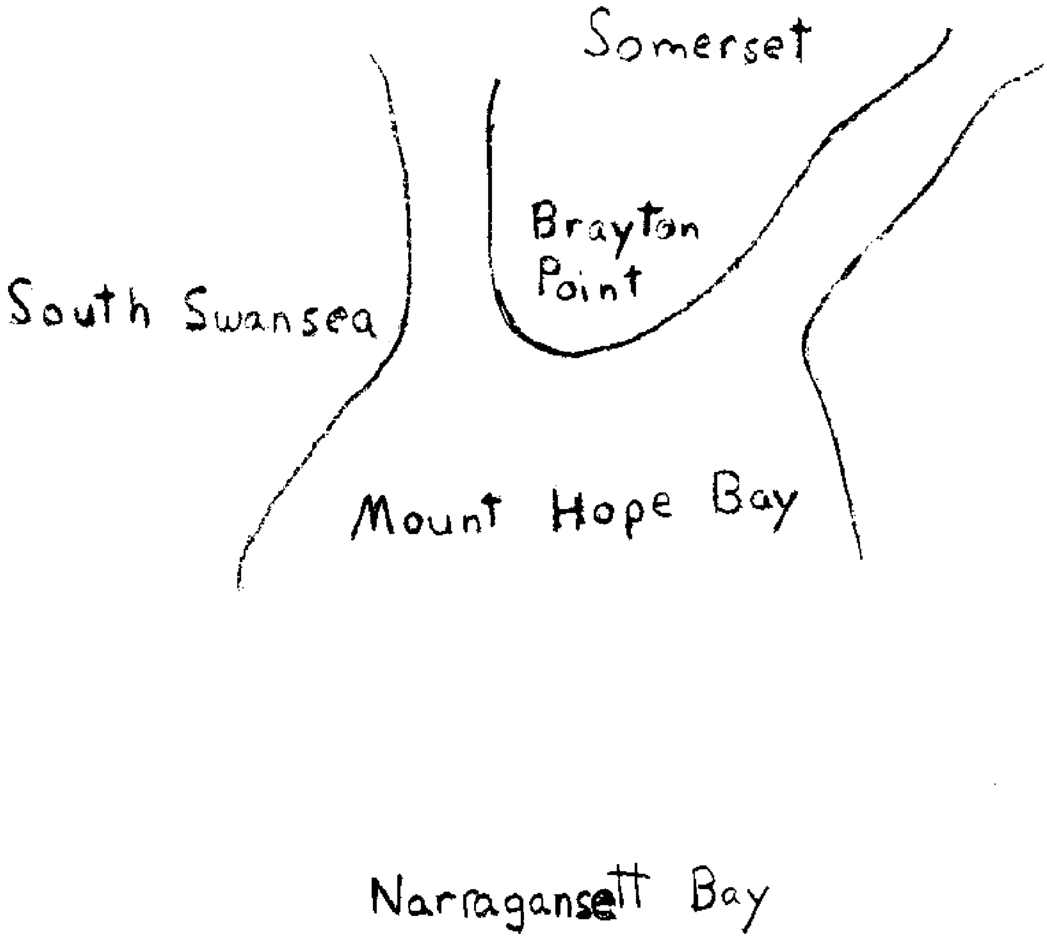
In the early sixties the New England Power Company, a wholesaling subsidiary of the New England Electric Company, established 1590 mw of generating capacity at Brayton Point, Massachusetts on Mount Hope Bay, an estuary of Buzzards Bay. At the present time this is the largest fossil fuel plant in New England. A conversion from coal to oil was made several years ago. In 1968 proposals were advanced within the power company for the erection of a fourth unit of 465 mw to begin operation in 1973.

Although the plant was located in the town of Somerset, problems arose from complaints from across-the-river neighbor of South Swansea. (This author finds it interesting that there does not seem to be much complaint from Somerset, and he tentatively agrees with the utility company that the major cause of this phenomenon is that Somerset is collecting property taxes from the power plant and South Swansea isn't.) In any case, South Swansea residents complained of noise, air pollution damaging property and health, oil spills, unaesthetic construction, bothersome lighting at night, fly ash deposits (from boiler cleanings) depositing on the bathing water (South

Swansea has a river beach), algal slime in the bathing water caused by thermal effluent, and uncomfortable hyper-heating (to 98° F) of the bathing water. The utility company, while agreeing that air pollution complaints were originally justified, feels that it has corrected the situation enough so that there is no longer reasonable cause for complaint. It does not feel that the water pollution problems are too serious. It feels that readings taken by the plaintiffs and some of the agencies are untypical; it feels that the agencies' interpretation of the fish kill data is distorted.

The record of complaints finally produced an abatement order in October, 1970, concerning heated discharge, fly ash, and oil spills. The utility company agreed to construct a diversion canal. Other ameliorations were put in. Total additional expenditures involved were about $2,000,000. Simultaneously, New England Electric proposed the construction of a fourth unit at the site. The interveners felt that the power company was simply trying to use the ameliorations as a foot in the door for expansion. The utility company feels that it is clear that the site is the best site for its power system coordination, and that planning had been on-going since 1968.

On February 11, 1971, the Division of Water Pollution Control decided that a fourth unit was out of the question. By early April it had reversed this decision. This reversal was opposed by Marine Fisheries. The Director of the Department of Natural Resources backed Water Pollution Control. Why



the switch? Some interviewees felt that water pollution control people, like their agency ancestors in public health, are politically appointed animals and therefore most easily subject to political pressure. It was felt by some that the utility companies had exerted pressure on the governor. On July 8, 1971, a case was filed in court to stop the fourth unit. The utility company and some of the agency people feel that the true purpose of the interveners is to stop all operation of the plant. New England Electric feels that the real irritant is air pollution, and that water pollution is being used as a basis for legal challenge because the law is stricter in that area. The legal counsel for the plaintiffs does not agree that there is any subterfuge of true cause for complaint, but he does admit that the water pollution case is easier to present than the air pollution case. The Division of Water Pollution Control has never had a previous complaint about hyper-heating of bathing water.

After the case was filed, the Environmental Protection Agency became active. EPA seems to say that it had been interested in Brayton Point for a long time, and in fact there is a water pollution monitoring station on nearby Narragansett Bay. Legal counsel for the interveners says that EPA became involved because of the interest in the court case of two devoted environmental lawyers with the local EPA. The utility company feels that EPA became involved because of the very presence of the laboratory, whose interpretation of the data comflicts with that of its own technical advisors. EPA says that it is interested in protecting and cleaning up the whole estuary, and that action against the utility company is but the first of a series of steps to restore Mount Hope Bay.

During the permit granting and technical committee process, several sources of inter-agency conflict arose. There was the forementioned conflict between Marine Fisheries (Massachusetts) and Water Pollution Control (Massachusetts). Curiously, the latter says that it takes Marine Fisheries' objectives into account in its decisions. Marine Fisheries denies this. This author feels that Marine Fisheries welcomes EPA intervention and the suing of the Department of Natural

Resources. Another source of argument are the criteria concerning thermal effluent control. EPA has advanced the concept of a mixing zone whose heated coolant water is allowed to mix with a fixed area of a natural water body under the condition of a constraint on maximum temperature increase. Spray modules (at a cost of $1,000,000) will be installed in a much expanded diversion canal ($6,000,000) to decrease the water temperature enough so that the small mixing zone can meet EPA standards. Marine Fisheries opposes the idea of a mixing zone because it considers such a grant a license to kill. The state agency feels that the proper criterion is maximum temperature at outfall. Even if Marine Fisheries were to accept EPA's concept it feels that temperature limits for the mixing zone should not be based on mussels - EPA's choice of sensor organism. It feels that national standards should be subject to meet local conditions. It advances the view that commercially valuable menhaden should provide the basis for temperature standards. Several agencies feel that EPA's standards are arbitrary. EPA feels that its standards are simply the performance of its mission in an uncertain world.

Apparently some agreement (at least in the eyes of some; EPA denies this) was made regarding Brayton Point. Then EPA found out that total internal recycling of the coolant might be possible and is now delaying a decision for one month until it finds out. This latter decision was made supposedly at a higher decision-maker level than the former one. EPA feels that it must update its rules for the better performance of its job and so that it can eventually establish guidelines.

Although all the agencies feel that the thermal problem will be fairly easily solved with enough capital expenditure, there will be great difficulty in dealing with the entrainment problem. Screens which could protect plankton, fish eggs, and larvae have not been developed. The utility company does not feel that the number of fish being killed is significantly high, but the environmental agencies do. The Bureau of Sport Fisheries and Wildlife proposed a barrier to prevent entrainment.

In this author's interviews with the agencies he formed the impression that the long-standing Bureau of Sport Fisheries and Wildlife had an excellent awareness of engineering and delay costs. Both it and EPA were well aware of administrative costs. Marine Fisheries had a good idea of engineering costs. All the interest groups had different ideas of the lead time involved in the siting process, and all of them, including the utility company, probably underestimate this lead time because they underestimate the complexities of the system's decision-making process. In the meantime New England Electric had about $5,000,000 invested in constructing a new unit at Brayton. Now, an additional $20,000,000 of equipment has been ordered. Whether or not the plant is actually built, interest will have to be paid on the bonds required for the additional investment. Some of the agencies feel that the assumption of such a large investment reflects an insensitivity on the part of the power company to their environmental views, although they generally had fairly high regard for the cooperation of the power company. The utility company feels that it is only doing what a complex system design requires it to do. However, it says that if it knew what a mess it was going to find itself in, it would have gone elsewhere. Now, it insists it is too late. It appears to be confident that although the legal process may take another two years, the fourth unit will eventually get in. It thinks that the need for electricity is so powerful and the Brayton area unemployment rate so high, that it will win out in the end. Most of the agencies are of the opinion that the fourth unit will never get in. Some of the interveners regard the issue as the continued operating existence of the current three units. There is a general feeling among environmentalists that the growth of energy utilization will have to be constrained. New England Electric is willing to meet all environmental demands on its fourth unit, and is willing to construct a diversion canal for the whole plant, but it does feel that it should not have to redesign the currently existing three units to meet higher environmental standards (at a cost of $1,000,000?), which demand the EPA is making. It feels that the proper criterion is whether or not it is a better neighbor as the old three-unit plant or the new four-unit plant. The federal agencies and the state Division of Marine Fisheries consider that the entrainment problem is so serious that the latter cannot possibly be a good neighbor. Some of the agencies sympathize with the company's problem, and consider that they should provide it with an alternative. Others feel that the utility is paying for environmental blindness.

The Brayton Point addition was originally scheduled to cost $65,000,000. Now a cost of $90,000,000 is projected. $10,000,000 of the increase reflects environmental modification costs and the other $25,000,000 reflects interest and inflation. In addition, because of the simultaneous problem of a lag in revenues caused by the Price Commission, New England Electric is undergoing the financial squeeze (the nature of which is explored in Chapter V).

CHAPTER V
MANAGEMENT PROPOSALS FOR APPROACHING FINANCING AND ENVIRONMENTAL PROBLEMS BY THE ELECTRIC UTILITIES

Utility companies view their expansion activities as the cornerstone of American growth. Utility views of the value of a MW of electricity run as high as the term "GNP divided by aggregate electric capacity". Theirs is a highly capital intensive and technologically based industry, qualities which Americans have a tradition of admiring. Because power expansion is a job for engineers, utilities have traditionally been controlled by engineers, although the last decade has seen some shift in the occupational identity of the man at the helm. In response to the increasing intensity of regulation problems, lawyers and finance people have been making their way to the top.

It is universally recognized that finance is the key issue of the utilities' profitability and even continued existence in their present form of ownership-control. Heavy new financing is required both to finance new construction and to refinance (at 3 to 4 times the old interest rate) a wave of maturing debt. Thus an industry which has traditionally been regarded as being "soft" because of its monopoly-like nature (though there is competition in the industrial market sector) today finds itself having to grow at 7% a year--$100 billion current dollars of investment in the next decade--in an often hostile climate. Utility people feel it is necessary for them to grow to meet their projected demand (They do the projecting.) because (1) inability to satisfy increased demand will stimulate politically sensitive rate-making bodies to cut their profits (2) meeting the load is a matter of professional pride.

As indicated above, financing is viewed as the major problem. However, the financing problem seems to be viewed as an engineering problem rather than as an art - how do you raise funds in the capital markets twice as fast as you've raised them before, especially when your coverage constraints* are tighter than ever because of project delays and currently (and for the foreseeable future) high interest rates?

In the context of project delays, we see four classifications of costs. One is just the additional interest on extended construction (which must be capitalized rather than expensed, a less than optimal procedure for an industry which has no need to make its assets look larger on the balance sheet). Another is the environmental modifications which must be added to the power plant in order to obtain licenses from the environmental agencies. These average 10% of investment. A third, which sometimes is a savings, is the change in cost of construction labor and capital equipment. The fourth is the opportunity cost of delayed revenues. Although these "delay" cost overruns are running at a national average value of 20%** for nuclear plants and somewhat less for fossil fuel plants, it is their implication for financing which is most

* see p. 35 for explanation.

**Source: William Lowe, partner, Pickard and Lowe.

significant. The general rule for meeting S.E.C. regulations on long-term debt is that the annual interest payable on such outstanding debt is limited to one-half of operating income after taxes and before interest.* Thus an increase in operating and construction costs and a delay of expected revenues from new operations will not only reduce profitability for the current year (which can in part be counterbalanced through "flexible" accounting), but it may also delay current and proposed projects and reduce future financial flexibility. Short-term borrowing can be substituted for long-term debt only up to the S.E.C. constraint of 20% of capitalization. Many utility companies prefer to use short-term borrowing first so that flexibility with respect to long-term operations can be maximized. However, most utility companies view their operational financial constraint as the credit rating, which is the basis of their short- and long-term interest rates, which underly their cost of equity capital, which is the return on risk required by the investor for a similar risk class of companies. Credit ratings are based on a number of factors of which the leverage relative to the aforementioned maximum permissible debt ratio is probably the most important. Utility companies tend to interpret this factor as the key to the all-important credit rating.

The utility industry's response pattern to current financing problems have been lobbying for a permit superagency,

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*Mortgage bonds also often contain clauses specifying coverage constraints and debt ratios. Debenture issues are one way of avoiding these constraints, but debentures carry a higher rate of interest.

cooperative ownership of atomic power facilities, and hopes for a consumer rebellion against the causes of rising costs of electricity. Recently, Commonwealth Edison of Chicago offered "custom-tailored" debt securities (in terms of interest rates and maturity and the convertible market) to attempt to attract new sources of funds (e.g., the small investor). But even such a relatively simple strategy as this kind of security marketing has not been generally emulated. In any case, it is probably of limited potential.* Increased efforts at marketing of product have also been made, but these have sometimes abated when faced with environmental opposition or the implied increase of peak demand (which raises required new capacity).

Generally, utility planning and financing have continued on their traditional basis - a specified capacity is somehow decided upon, present values discounted at the cost of capital of 20- to 30-year projections of costs for alternative system designs are screened for the lowest PV, which is then financed for construction. No cognizance of the particular alternatives' characteristics on financial strategies or, through the regulatory system, on revenues.** Financing is

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*A few years ago ATT announced it was going to issue "security bonds" in denominations of $100 and paying 7% interest. These could be purchased at ATT business offices. Uncle Sam promptly pressured ATT not to go through with the proposal.

**The regulatory system responds differently to "fixed investment" costs and annual operating expenses. This is not the fault of the present value analysis but of the regulatory system. Nonetheless, the profit maximizing utility should respond to this rather curious system rather than ignore it in its investment planning.

accomplished through the use of retained earnings, equity issues, and debt (short- and long-term) issues. We feel that this management system is inconsistent with profitability in the current environment of financial distress. We feel that a planning system which embodies assets which are highly capital-intensive, which are subject to such a high level of time dispersion of the critical initial revenues and costs, and which are subject to regulated rather than market price adjustments, demands the integration of the financing problem into the engineering system planning itself. From the point of view of the utility, the objective should be the maximization of net present values of revenues less costs. The remainder of this section will be devoted to an exploration of financial strategies as tools for a wide range of sensitivity analysis on the costs of factors of expansion. In order of what we believe to be their potential impact, these tools are the cost analysis of the risk underlying expansion, cost control, and leverage. In order to establish the fundamentals of our approach, we will illustrate the last tool first.

The cost of capital is the weighted average of the cost of raising funds. A price must be paid for borrowed money - interest. A price must be paid for equity - the required rate of return on equity, which includes dividends.* A price must be paid for the use of retained earnings - the direct cost of raising new funds to maintain dividends and/or the opportunity cost of not investing the retained earnings in external investments/securities. The cost of capital must be less than or

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*$k_e = \frac{R}{p} + g$, where R = returns (dividends)
p = market price
g = expected growth of returns

equal to the rate of return on investment if the company is to make a profit. If the perceived rate of return on investment is greater than the cost of capital, then market price will be bid up until ROI = k_o (k_o = cost of capital).

From the investors' (either of bonds or equity) viewpoint, the required rate of return (k_i or k_e respectively) from ownership of the security is based on the risk-return-on-investment package of the particular company relative to companies with the same level of risk. Market valuation of a company with relatively high risk attached to a particular level of return (on securities, i.e. on assets) will decrease until the rate of return on the security rises to the appropriate risk-return relationship. Risk is evaluated through the expected dispersion of the company's future earnings, the danger of its financial bankruptcy, and the effect of its ownership on the security holder's risk-return portfolio. Debt holders bear less risk than shareholders because of their legal priority in income and liquidation. Therefore the required return of the former is less than that of the latter. Debt is also cheaper to the company than equity because interest payments are subsidized by the government as tax deductions from income. A company with a high credit rating is perceived by the investor as having a low risk.* Therefore such a company has a low cost of capital. The temptation to increase debt relative to

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*Sometimes mistakes are made, as in the case of the Penn Central, which enjoyed a high credit rating despite a high risk of bankruptcy.

equity in order to lower the cost of capital to obtain a higher return on equity (i.e., maximize shareholders' wealth) is resisted according to the fear that increased leverage will decrease credit rating which will increase the cost of capital beyond any tax savings of debt. On the other hand, utility companies are pressured by politically sensitive rate-making bodies to deliver their product at lowest cost, which implies the necessity of a minimal cost of capital. Utilities want a low product cost because they feel that they are in a competitive market (at least in the industrial sector) and that a lower price will guarantee them the cost-efficiency of serving big customers according to their assumed high elasticity of industrial demand for electricity. Another factor which should not be discounted as a motivation for low prices is the sense of engineering professionalism related to cost efficiency. However, utilities do not like to decrease the cost of electricity by borrowing more. The high credit rating has joined the stable dividend as the credibility symbols of utility management. This decision is not reached via a quantification of tradeoffs between the cost of increased risk and decreased weighted cost of capital; it is an assumed business more. The questioning of this kind of behavior is especially relevant for a growth industry, where shareholders will accept a lower rate of dividend payout return in exchange for the capital gains expected from the growth. The electric utility is experiencing a long period of sustained growth. Additionally, revenues from its product are extremely stable. Thus the risk factor attached to electric utility security ownership, even with the noise generated by growth, cannot, under "normal" circumstances of market interaction, be especially risky. (We will explore the significance of "normal" market circumstances below.) It does not appear that the utility industry regards leverage as a potential financing tool. One excellent justification for this prevailing attitude is that any increased profit will be taken away by the rate regulators. Perhaps this regulating behavior ought to be lobbied against. Standard leverage and dividend payment seems to be a rule-of-thumb art practiced by the same thumb for all companies.

Expansion policy is a potential dimension for financing strategies. Manipulation of expansion is currently regarded as taboo. Yet if expansion is the underlying cause of sleepless nights for utility treasury officers, then it ought to be looked upon as the key to alleviation of their problems.

As indicated above, expansion is decided through the use of minimization of present value of technical costs. Although present value techniques (e.g., discounting at opportunity cost of capital, sensitivity analysis on costs) are generally the correct decision tool for investment, we feel that there are two large problems in their current application to the utility industry. Typically, factors tested for sensitivity analysis are fuel cost, optimally efficient size of plant, capacity distribution between base and peak load, alternative site foundation, cooling, transmission, and land costs.

However, the currently major components of cost dissipation from projected expected values - project mismanagement,* environmental intervention,** and labor construction,***have been left out of the sensitivity analysis. Furthermore, there is no attempt to tie in financing constraints into expansion policy, e.g., what happens when a project is delayed so much that revenues to finance new debt cannot be raised? What are the politically determined costs of not having enough capacity? What are the consequent marginal costs of overworking current capacity and purchasing electricity to cover the gap in capacity? What will be the effect of this kind of embarrassment on the credit rating? And finally, this author has not seen any attempt to relate regulated profitability to present value calculations. Briefly, regulation guarantees coverage of "normal" operating costs, depreciation, and taxes plus a return on investment (equal to the cost of capital) of depreciated assets. Profit is made on the uncertain elements of expenses through application of the rate of return on the working capital required to finance them. What system planning ought to do is calculate the rate base of alternative systems (i.e., potential profitability), test for sensitivity probable future rates of return and expectations of the rate regulators'

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*one plant in Kansas had a 200% cost overrun because of technical and managerial problems.

**delays from environmental intervention are causing 20% cost overruns; some plants, as in our case history, are running at 40% cost overruns.

***construction rates have been increasing at 12%/year.

acceptance of particular components in the rate bases, and evaluate the differential financial pressures of alternative systems of assets and their concomitant operating expenses. Yet it seems that this entire issue has been neglected in system planning. One regional study shows less than 10% sensitivity in favor of a nuclear-based system.* (We have already examined the inadequacy of this sensitivity analysis.) It is possible that in terms of profitability and ultimately in terms of market valuation this differential might be much different in either direction. System planning (even when given the required capacity should be based not strictly on present value costs but through an analysis of the meshing of costs with the regulatory system. Surely the utilities realize this fact of regulatory life. Yet this author has not heard anyone talk about it, much less quantify it. System planning for a business ought to relate to profitability of the business. Present values of costs ought to be partial inputs, not outputs, of expansion policy. Tradeoffs between financial and asset structures and profitability ought to be evaluated. System planning should be performed within the context of the relevant political-business environment.

Another potential expansion tool for alleviating the finance problem is the benefit-cost analysis of reliability.**

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*New England Power Pool, Interconnected New England Generation Study, Generation Task Force #4, for the New England Planning Committee, May 1971.

**Michael Telson of M.I.T. is working on this subject.

The traditional and widely used standard for an adequate reliability index is a probability of system failure of one day in ten years. Reliability is measured by capacity reserve for maintenance and forced outage. Decreased reliability means less expansion which means less required financing. Decreased reliability can also mean an antagonistic rate-making body. Nevertheless, there should be some room for leverage and even for tradeoffs. The benefit-cost analysis of reliability can also be applied to evaluate the value of pooling efforts.* A problem here is that the current rate-making structure does not generally give profitability on purchased or interstate pooling of electricity. Perhaps more clever pooling arrangements and more lobbying in this direction might be undertaken.

Expansion and particularly nuclear expansion generate costs which do not appear in the current "present value" calculations. If everybody needs additional capital and construction labor for more expansion (nuclear power requires almost twice the initial investment exclusive of air pollution control equipment per MW than fossil), the aggregate effect on these markets will be increases in rates. The recent soaring of construction labor costs is partly due to the heavy demand for pipefitters to construct nuclear plants. While the $30 billion dollar bond market (most current expansion is financed through debt) can easily absorb another billion or two without a general rise in interest rate, what will be the

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*e.g., NEPOOL; see footnote on p. 66.

combined effect on interest rates of an annual increase in demand of several billion from the electric utility industry and several billion more from the housing and gas and oil industries - increases which may well be occurring in this decade? Sensitivity on the cost of capital as related to aggregate demand for capital is required. More importantly, sensitivity analysis of the cost of capital is necessary because the utility industry itself may be becoming increasingly viewed as a riskier investment. Interest rates on utility bonds are greater than the rates on industrial bonds having the same credit rating. This increase in perceived risk is potentially greater than any small leverage effect. Its sources are the uncertainty surrounding the returns of expansion, the analysis of which is currently omitted from the system planning. The utility industry will probably respond with higher dividend yields, but this tactic will cost it retained earnings as a source of funds. While the rate-making bodies will generally grant requests for rate increases to cover increased cost of capital, there can be costly lags (Rate increase decisions can take six months to several years); there may be pressures for closer government supervision.

The remaining area of relief for financing is in the control of costs. We consider this an appropriate area for financing strategies because of significant effects on the use of assets and environmental policy. Currently, maintenance scheduling is based on an activity space rather than on cost.

Effort is concentrated on keeping the system going rather than on evaluating its cost. We are not suggesting that a policy of short-term value like minimal maintenance be adopted, but we do not see why maintenance cannot be scheduled by cost.*

Delay costs are costs resulting from inefficient control. While mere expansion in itself will tend to increase the dispersion of delay costs, we feel that the utility industry is handling these costs inefficiently, particularly with respect to environmental management.

The utilities regard environmental protection in the abstract as being of real social value, and hence (pragmatically) accept the concept of such regulation. They do object to uncertainty surrounding such regulation at the present time. They do object to the lack of sympathy for their objective--producing power--which they feel the regulatory agencies and a "small" part of the public demonstrate.

However, when it comes down to the nitty-gritty of environmental regulations, we feel that there are several obstacles in the thought processes within the utility companies' attitude which serve to diminish the efficiency of environmental regulation concerning their pocketbooks. The power companies don't understand the objectives of the agencies which they deal with. While they laud the concept of environmental protection, they have very little idea of what the set of specific environmental

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*Jim Gruhl of M.I.T. is currently working on scheduling maintenance through cost analysis. His analysis includes environmental cost, and he finds that the weight and dispersion of values of the latter are extremely significant.

benefits consists of. This mental state partly stems from the absence of explicit agency guidelines and partly from the two sides' entirely different objectives. The consequent lack of real sympathy with the regulatory agencies serves to increase the potential for antagonism. More importantly it leaves the agencies and interveners as the only initiators of measures for environmental protection. The power companies have passively tossed the ball to the "other side", and in so doing they have permitted the other side control of timing and procedures. You can't play a game when you don't understand the motivations of the other side. Empathy is the best vehicle for such understanding. Sympathy is a good substitute. The power companies ought to initiate more moves for environmental protection. One potential tool is the utilization of waste heat to compensate for negative environmental effects. Further discussion is reserved for Chapter VI.**

The power companies regard the environmental regulatory scenario as just the latest element in the business game. They see sessions with the agencies as a matter of give-and-take between political powers. Aside from playing an inefficient game, they do it badly.

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*This author asked a number of utility managers to list the benefits of environmental regulation - after they had praised it. They didn't come up with a very long list or even any at all.

**LILCO has initiated the use of waste heat from its Northport facility to raise oysters, thus hoping to placate environmentalists. However, this kind of action is spotty. Furthermore, as in the LILCO case, it is often part of an inconsistent environmental policy. LILCO also dumps sulfuric acid which was used to clean the boilers into Long Island Sound.

1) They underestimate the ideological commitment and growing power of the environmentalists.

2) As already indicated they have left the initiative in the hands of the environmentalists, which in a pro-environment legal scenario, will be a costly thing for them to do.

3) They see the situation (quite correctly) as one of tradeoffs between an uncertain pattern of environmental costs and very uncertain delay costs; they underestimate the average value of those delay costs. Point (2) also contributes to the uncertainty of the environmental costs.

The power companies suffer from a lack of imagination in dealing with the environmental agencies. Their chief alternative seems to be a one-stop superagency which will presumably consider all objectives, with a priority for the need for additional electric power.* In doing so, we think they fail to appreciate the possibility that such a superagency may be so powerful as to end up running their business. Underestimation of the environmental forces lies at the root of this problem. Business feels that such an agency will have large public exposure and consequently will be sensitive to the expected outcry against rate increases caused by environmentally

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*One interesting exception was the strategy of American Electric Power whereby a nuclear plant was planned beyond projected capacity needs with the calculation that either it would be delayed and thus would come on line in time or it would come on line as expected and then its production could be sold to neighboring utilities.

induced modifications. This argument is a subtle one. It might work. What are the costs to a company if its one plan doesn't work? Suppose the powerful environmental forces rally around the superagency? A rich organization is better off fighting decentralized battles.

The establishment of one superagency would not exclude the diversity of environmental interests. Decisions may still have the same forementioned problems. The importance of hierarchical decision-making would be vastly increased. (See Chapter VI for an analysis of regulatory agency decision-making.) The utility industry expects that an authoritarian regulatory structure will benefit it because of the presence of fewer actors in the system and because hierarchical decision-making, in order to avoid the decision overload such systems are prone to, tends to develop general guidelines which don't really examine problems in detail. On the other hand there may be additional delay because of decision overload - either as paperwork or unwillingness to make spotlighted decisions.

Another tentatively identified major source of problems of the industry in dealing with the regulatory agencies is that because of the very nature of the utility company structure, costs are considered in either financial (accounting) or very technical engineering terms. The vocabularies and measurement units of these fields are obstacles in the consideration of basic economic tradeoffs for long-range planning and for dealing with the environmental agencies. Neither of these fields is suitable for across the table deals in which economics and the environment can be connected in one function used by both sides. It is because of this problem as well as that of attitude that the power companies seem to be poor players. The power companies must broaden their objectives to create room for the inclusion of all elements of the game. The mere drawing up of an environmental policy integrated into the system planning might go far toward broadening the utilities' views and alleviating mutual distrust and consequent economic loss.

CHAPTER VI

A SOCIAL MANAGEMENT FRAMEWORK FOR REGULATION OF THE ELECTRIC UTILITIES

Section 1 - Overview

Electric power is a big business in this country; the privately owned sector, which accounts for about 70% of total electric power assets, currently grosses over $20 billion in annual revenues and constitutes 6% of gross private construction and durable private investment (and about 12% of net additions to capital stock). Because we have an economy characterized by capital intensity, luxury products, and high locational mobility (because of its facility for distribution) assumes an obviously important role in our society. In the past regulation and planning in the utility industry have responded to this role through objectives of cheap energy, sufficient capacity expansion, and reliability of supply. Today, the recognition of resource constraints in the ecological web of man and his environment and in the primary energy and capital markets has stirred increasing demands directed at the government and the electric utility industry for the incorporation into the operation of the energy system of solutions to a variety of problems ranging from soot to the price of oil. This "energy system" has been generally unable to bracket problems and approach any structured decisions involving the cost of capital, the oil quota, construction labor inflation, the reality of forecasted brownouts, thermal pollution, land aesthetics, water pollution, a possible shortage of water for coolant systems, NO_x, SO_2, particulates, regional or national grids, oil development, fossil and nuclear research technology (There is a lot of work going on in these technologies, but it does not appear that the quantity of research funds put up by the utility industry, other private sources, and the government is commensurate with the potential benefits of efficiency),* safety features of nuclear plants and urban location (the problem here may be one of communication), antagonisms toward big industry, indifference by government and industry to the private citizen neighbors of power plants, coordination between state and national licensing bodies, the internalization of real (resource) costs into energy pricing, amelioration of economic regulation to provide incentives for efficiency or concern with the impact of large increases in the price of electricity on the citizens of Harlem or the rural poor. The energy system has resulted in a lot of discussion which has not advanced very far in operational concepts and in a lot of activity at the "system's" points of greatest visibility (e.g., the power site, offshore drilling), i.e., the points of potentially the greatest external leverage. The purpose of this chapter is to set up a framework for decision-making so that we can have an effective system of power management. Underlying this statement of purpose is the assumption that the real constraint of the energy system, including the electric utility industry, is

*A 1% increase in national average efficiency for power plants would mean an annual savings to consumers of about $50 million/year. The electric utility industry currently spends less than 1% of revenues on research.

the conceptual-operational structure of government and private industry management.

One problem basic to the organization of any complex process is that the answer (and more importantly, the approach) to the query "What is the problem?" tends to be restricted in scope to cover only the area of interest of the person who asks the question. Each party has his own subset of facts. Questions which are basic to some persons and interests are irrelevant as proper problems to others. The latter tend to accept them only through coercion. This situation results in what is commonly known as "talking past each other". Thus there is a barrier to establishing the factual basis to make tradeoffs between values; even were these tradeoffs established, there would be difficulty for many in accepting them. Thus one environmentalist can say that all air pollution must be stopped (Does that mean industrial production too?) and one former utility man can say that he sees negative benefits in environmental regulation as practiced.

Even if everyone were educated to appreciate the entire range of problems and even if everyone could appreciate these problems from everyone else's viewpoint (i.e., common objectives), there would still remain two major problems - (1) given that the above energy-environment-economics problems result from the recognition of resource constraints, it is apparent that there must be tradeoffs between objectives; it is impossible to have everything. How can any public or private body make a decision(s) which involves the consideration of all of these problems. (2) Even if a managerial ordering of decision-making for the full range of problems is achieved, how are the criteria of decision-making to be devised.

Although many people have already criticized the Report of the Committee on Power Plant Siting of the National Academy of Engineering and the benefit-cost guidelines for nuclear power plants of the Atomic Energy Commission, let us briefly review these documents to illustrate points one and two; more sophisticated proposals dealing with management of the "electric energy system" do not appear to exist.

The COPPS report looked at power plants in the context of environmental effects and energy needs and economics. Its recommendations were basically the same as those which have been circulated around for some time in one form or another in legislatures and journals - one-stop licensing and more research and development to develop alternative technologies for treating pollutional problems and to devise standards for energy pricing which include social costs. Everyone says there should be more R & D. Who will pay? Currently the electric utility industry invests about 1/2 of 1% of its gross revenues in R & D. Most research effort is undertaken by the government, whose efforts tend to be channeled along the heavily political route of the agency or bureau structure.

The potential direct bearers of research costs are society directly through government, the utility companies as middlemen buyers of technology and sellers of its product electricity, the manufacturers of power equipment and the exploiters of primary energy, and the final user of the power, whether that product is electricity itself or a train. The determination of the identity of the direct bearer of cost is essential for consistency and efficiency in the control of market behavior, the direction of research effort, and the establishment of a "contribution" (i.e., taxes, rates) structure for financing research which is consistent with energy policy. Unfortunately, COPPS did not explore these ramifications of "more R & D".

One-stop licensing bills have been "on the drawing board", in committee, and out of committee for several years.* Essentially they propose to merge a variety of interests into one agency and to require longer periods for pre-construction hearings. Presumably this reorganization would diminish duplication of effort and operational delay. Some bills propose a combination of the rate-making and all environmental agencies; others seek just to combine the environmental agencies. Because the utility industry needs help badly (In January, 1972, 83 plants were delayed or inoperable.) and because cure-alls (especially legalistic ones) seem to enjoy a tradition of popularity in this country, numerous utility executives and legislators toss around the magical phrase of "one-step licensing". Some of the more sophisticated utility people, however,

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*Power Plant Siting in the U.S., 1972, a Summary, Southern Interstate Nuclear Board, contains an excellent discussion of the subject.

suggest that a one-step agency will be as inefficient as the current system unless standard procedures and regulations are adopted. Otherwise the reorganization would merely place disparate interests (as shown in the case history, even fish protection and water pollution agencies can sharply disagree) in closer proximity and even greater conflict could occur. A greater time allotment for decision-making--in the absence of clear decision-making rules--will not automatically make decisions better ones. Perhaps a one-step agency will serve as a rallying point for the environmental forces, who are too weak to fight utilities in decentralized battles? Then again, as many environmentalists fear, over the long run a one-step agency regulating the utility industry might develop an agency-client relationship. The utility industry fears that if such a relationship does develop or if the licensing is particularly strong, perhaps it will be ruled, not regulated.

However, even if the superagency is able to achieve a workable balance of interests, a more fundamental issue remains. Rational decision-making can operate only via a set of benefit and cost (in the largest sense) criteria. While there may be disagreement over the appropriate items of benefits and costs or their measurement, benefit-cost analysis is the key to rational decision-making. Ideally, benefit-cost analysis treats only with real resource costs, that is, the opportunity value of the resources required to produce the service if they were employed elsewhere. In unregulated competitive markets, market price and resource cost will be approximately equal. On the other hand, if we are dealing with a good whose market is subject to monopoly power or regulation or taxation not based on the cost of the provision of public services, there can be sizable difference between market price and resource cost. It may be too high or too low, depending on what would happen in the market if regulations were relaxed and if there were a competitive market among buyers and sellers. For example, if the cost of the desulfurization of fossil fuel is so high because of insufficient funds for R & D because of a misguided market or that oil company collusion, then the high cost of sulfur removal from the fuel before (75¢/ bbl of oil [6,000,000 BTU]) or after combustion ($70,000,000 capital investment for a 1000 mw plant)* would not be truly representative of the cost of clean air. These questions are not merely rhetorical points. A superagency whose objective is cenetered around real national income should be making decisions based on tradeoffs of resource costs. Is it within the scope of any agency's power or intellect to decide on the validity of prices as representing real resource costs?

The Atomic Energy Commission is attempting to determine economic-environmental tradeoffs for power plant sub-systems. Its guidelines violate this intention by (1) benefit-cost inconsistencies like considering both local taxes and plant revenues (revenues include taxes) as benefits, thus double-counting taxes, which are really a redistributional wash to society as a whole (2) structuring environmental costs in such

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*Source: Frank Ritchings, vice-president, Ebasco.

a way as not to permit plant design-environmental impact tradeoffs between power sub-systems (3) not differentiating between plant operation and plant design in measuring "minimum" impact (which is undefined in the latter case) (4) not providing measurements of environmental impact in common terms so that tradeoffs can be facilitated.

This author finds these proposals inadequate as social management strategies. However, before putting forward our proposals for better management let us develop some underlying concepts on which to build a framework for analysis of the industry and for regulating decision-making based on that analysis.

Section 2 - An Internally Derived Concept of Large-Scale Management - Brief Analysis of Structure and Decision-Making Dynamics

We can define large-scale management as a process of executing large, somewhat unique projects through a coordination of resource inputs via an irregular flow of decisions timed by reference to standards derived from the major objective of the organization. The decision flow is irregular because the system is potentially subject to externally imposed bottlenecks (including regulation) in each of the resource markets. An additional source of bottlenecks can arise from repurcussions of barriers in the final product market. Bottlenecks necessarily arise because (1) the discontinuous and/or non-repetitive nature of the product inhibits the development of standard operating rules and procedures (2) the product and its resource inputs are visible enough to attract political attention (3) the management process has an extended temporal dimension which increases its exposure to interference (4) internal bottlenecks can arise because the production process is complex enough to inhibit the development of the multi-disciplined organization of information and of innovational reflexes.

The power industry management system consists of sub-systems of capital markets (for equity, long-term debt, short-term debt), the labor markets (engineers, construction labor), material resources markets (equipment, fuel, natural environmental resources), and the public image market. Each sub-system is a complex of market forces operating under regulatory and traditional (the professional mores) procedures. While there are ultimately interactions between the sub-systems, they operate independently from each other in the context of daily policy and decision-making. Each sub-system is handled within the company organization by the respective department. Currently, the major resource bottlenecks encountered by the departments in their interaction with their environmental sub-systems are the raising of funds for expansion and the use at the power plant site of the natural resources of air and water. The departmental timing of decision-making--and consequently its quality--for planning, financing, maintenance, and legal proceedings is controlled by the key objective - the satisfaction of projected demand.*

*See Chapter III for a discussion of the normative behavior of electric utilities.

The interpretation of this objective has a fairly sympathetic vibration throughout the company hierarchy. It is deeply professionally ingrained in the engineers who do the projecting and planning, in the engineers cum environmentalists who head the new environment departments, and in the Treasurer's Office, which views its job as purely the financing of growth and its accounting treatment rather than its management. Although the company's homogeneity of attitudes promotes internal harmony with respect to carrying out decisions, such harmony is bought at the price of constraining the field of strategic maneuver of those departments where the primary bottlenecks are being encountered.

If we accept the above conceptual view of the management and normative behavior of the utility industry, then the problem vis-à-vis regulations to set up a social management system fitted to the character of the organization to be regulated and therefore sensitive to the manipulation of its decision-making process are resource needs for the long-run benefit of society. In setting up our model we want to take the broadest view of management of the utility industry in the energy-environment-economics picture. We want a broad view because we want to be able to set up the foundations of a system which can reach equilibrium - we want workability. Let us look at some currently limited approaches and their consequences.

We feel that many environmentalists exaggerate the importance attached to attacking power plants. Power plants are but a product of a whole cultural and economic system. The halting of the construction of new power plants often results in overtime for older, dirtier plants; perhaps the environmentalists are inefficient even on their own grounds. Also if environmentalists are unable to clearly evaluate the implications of their behavior, there might be an eventual backlash against certain environmental regulation.

Regulatory response requires a broad view if society is to use its resources efficiently. Regulatory response includes the incentive implications of rate and accounting structures, environmental regulation, and the relationship between public interests and government structure. Is it efficient for the rate structure to cover all operating expenses? Is a 1% limit on temperature increase (as proposed for Lake Michigan in 1970) of a water body efficient? Is it biologically meaningful? Assuming society has a viewpoint on thermal effluent, is the temperature criterion relevant to the desires of society? If society doesn't have a viewpoint, should it be educated to have one? Should the public be involved in regulation? If so, at what level? What are the consequences if it isn't consulted?

The value of our proposed paradigm is in its approach; we do not purport to have "the" answer. Our objective is the construction of the ability to establish tradeoffs between national income and quality of life. Our design criteria include the necessary condition of minimization of long-term antagonism: we do not think it useful for efficiency or implementation purposes to assume a role for a dictator, particularly when that dictator will probably have the operational attitudes of a lawyer, engineer or politician. Our design is fashioned to maximize the potential coordination of societal and private industry interests. Thus although the proposed system is set up from the social point of view, there is an empathetic treatment of the utility industry so that this coordination can be approached. The model's conceptual framework is the previously discussed large-scale management system. Theoretically, the model is designed so that decisions can be made in an orderly manner: those decisions which are most amenable to national policy-making are planned first - at that level. Decisions made at the higher political level become assumptions for later decision-making. If decisions are to be challenged, then appropriate points in the system should be designated for challenge. These points should be the places where the decisions being challenged (if the issue is the interpretation of prior assumptions) or their controversial assumptions were originally derived. In order to broaden this concept of responsibility centers, the leverage points must be determined so that particular organizations--the ones which made (or should have made in the case of omission) the decisions being challenged--are subject to suit. The alternatives to this kind of system are a continuation of the current system of a "public veto" power by numerous interests at the final stage of the process or the complete blocking of the right of public intervention. We do not envision a system of intervener (or even agency) participation gone wild. Challenges will be required to be specific to the decision-making area. Specificity should promote a battle between experts rather than a shotgun approach. Finally the form of the jurisdictional bodies which make decisions and which hear suits should be constructed so that decision-making is matched with the most efficient forms of decision-makers. The system should also be structured to encourage informal contacts for communicating feedback flows of attitudes and information.

Of course this proposal means that some organizations would experience loss of power. In our capacity as students of economics we are concerned only with efficiency and not with the political balance of power. But in our capacity as implementers we are concerned with our model's political feasibility. Therefore, rather than solely promoting outright reorganization of all existing decision-making bodies (which action might be ineffectual anyway because old-line organizational attitudes will filter into the "new" organizations via the flow of personnel), we will also attempt to derive increased efficiency through maximizing agency competition where appropriate and always through a clear delineation of decision-making guidelines. Because of the complexity of this kind of macro-organization and our lack of experience in this field, we do not intend to propose "the" final solution. We will sketch a framework of approach based on a priori logic. We will discuss the kinds of activities which should be undertaken in each sector of management with particular attention to an explicit benefit-cost analysis at the power system planning level.

Section 3 - The Model, Stage 1: Determination of Standards

More concretely, our model envisions the determination of technical and environmental standards at the national level (stage 1) through an analysis of resource costs via a central energy administration (with appropriate Congressional liaisons) and the Environmental Protection Administration (with appropriate support from other environmental advisors). These standards would encompass all the major elements of power systems and their implications. They would include (either as specific values or as guidelines for their calculation) the costs of the various kinds of pollution abatement equipment, marginal costs of fuels, the social costs of the major kinds of environmental impacts (discussed in section 6), etc. The central energy administration would consist of sections which would encompass the current set of energy R & D offices - e.g., the Office of Coal Research, the R & D section of the AEC,* etc., and at least have high level connections with those offices influencing the supply and price of primary energy. The purpose of this leveling among energy forms would be the increasing of the potential for the efficient allocation of R & D funds.

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*Ours is not the first proposal for separating the research-advocacy section of the AEC from its licensing section.

Other sections of the administration would devote their efforts towards the development of direct and indirect pollution control technology, e.g., scrubbers and gas turbines. (Admittedly, the former might fall in the province of the EPA. Problems like this would have to be ironed out.) To maximize the potential for national efficiency, extra-utility oriented research in devices like fuel cells would also be guided by a separate section. The most efficient research effort would probably be one in which initial efforts were contracted out until in-house capability had reached an efficient potential.* Efficient research would require a strong management-oriented liaison group operating at a level between policymakers and scientists. An economic-accounting section also ought to be set up to advise on regulations of "energy-accounting", e.g., making and operationalizing policy regarding depreciation of anti-pollution equipment consistent with social values. Thus, stage 1 of our system constitutes a complete line of energy and environmental agencies, hopefully coordinated by impact target, and responsible for servicing promising areas of R & D within a broad scope of alternative industry-based and futuristic technological approaches. Our definition of "promising" includes the use of benefit-cost analysis of alternative energy forms within the context of environmental impact. The environmental context of current coal technology, for example, ranges from strip mining to particulates.

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*suggested by Professor Donald Marquis of M.I.T.

Hopefully, standards developed at stage 1, when applied at stage 2, would prohibit the type of "decision-making" witnessed in the Four Corners power plant case, where strong opposition to a nuclear plant in California resulted in the transfer of the plant to New Mexico and its transformation into a costly and particularly dirty fossil fuel plant (Over $50 million of air pollution control equipment has been ineffectively applied.) - to serve the electricity needs of Californians. A coordinated energy approach which allowed intervention at the decision-making point might have done society (and possibly even the AEC, which may find itself on the coals* in the future on this issue) the service of costing and constructing a nuclear waste treatment process for residue of atomic plants. Such planning probably would have been good publicity for atomic plants, unless it proved to be so expensive that nuclear power was shown to be less efficient than fossil power.**

There have been numerous papers on the allocation of R & D funds and the use of benefit-cost analysis to determine real resource costs in the absence of competitive markets or inefficient markets. It is not the purpose of this paper to

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*Pun intended.

**The AEC originally planned to store irreducible radioactive waste in lead containers in a salt mine in Kentucky, where it was assumed geologic movement and moisture would be minimal. Among other reasons, this plan turned out to be unpopular because the AEC could not satisfy Congress with its contingency plans for robot removal of the containers. It felt it was sufficient merely to claim the ability to build such a robot without actually building one.

derive a set of sufficient and necessary conditions for this kind of analysis, which we have proposed to be undertaken for the construction of stage 1 of our model.

Section 4 - The Model, Stage 2: Licensing

The second stage of the proposed paradigm is at the level of power system design. Perhaps systems ought to be designed on a regional basis with a shared grid, but we are a long way from this possibility from the regulatory viewpoint, although, as demonstrated by NEPOOL, some regional coordination of system planning can be achieved through private efforts.* Rate-making and environmental agencies are centers of political power and it is doubtful that a new power structure could be constructed totally outside the structures of our two-tier political system. Thus, political feasibility argues for some state licensing agency. On the other hand, benefit-cost efficiency argues for a regional licensing agency in order to better accommodate pooling of capacity and inter-state locational analysis. Our system is based on state licensing, although it can be easily adapted to regional administration.

We feel that regulation must be fitted to the essential nature of the regulated activity in order to mold it. Regulation should not exist to benefit the regulators, although this condition is too much a fact of reality to assume away

*The NEPOOL arrangement calls for sharing of the region's needed capacity expansion among most of the region's power companies according to their present share of the market. Penalties are attached to the non-fulfillment of this obligation.

in a model. Regulation can be used as a social tool for change, but if its objectives and behavior are too far outside the traditional structure of attitudes and too one-sided with respect to role, there may well be enough antagonism stimulated to prevent the realization of social goals. Regulation leaning too far in favor of industry will inevitably destroy its enterprise; regulation which is too opposed to industry will inevitably destroy the industry or, more probably, itself. A case in point is that of Lincoln, New Hampshire, where the town's only industry, a paper mill, was forced to shut down, allegedly under government environmental pressure. While paper mills can be obnoxious, it is not clear that society is better off when pollution standards are enforced without regard to consequences on income. While it is possible that the loss of value of income of the town's residents was more than balanced by the transfer effect of a gain in national income through more efficient usage (fishing, recreation, etc.) of a now cleaner river and a substitution effect to the town of the higher quality of life attached to clean water, there is no evidence that there were any such calculations. A federal study indicated that such industry is only of marginal value, but it is obvious that to the locality it was of more than marginal value. In this approach where no evaluation of the efficiency implications of environmental standards was made or advanced planning undertaken to provide for redistribution to affected localities of national income gains (or national willingness to pay for higher environmental quality), we see the potential for regulation to bury itself and its regulators' objectives in environmental backlash.

Design criteria for efficient regulation of power systems require the coordination of efforts of all the actors in the system. As demonstrated in the case history, coordination of the federal and state levels is a non-trivial and important task. Coordination of regulation with private planning requires a mutual understanding of values and a consistent set of regulatory guidelines. Coordination with the needs of the affected citizens requires formal communications structures and an informal sensitivity on the part of the managers. Our approach is designed to facilitate meeting these criteria.

Coordination of environmental regulation between the federal and state (or regional) levels of government can only be achieved through the complete surrender (or usurpation) by one of the parties of the right to determine standards and procedures or through an agreement specifying respective fields of jurisdiction. We feel that the latter approach has the greater political feasibility and the greater potential for social efficiency. The weight attached to the cleanliness of a beach will vary from one area to another. It should be the right of an area to decide how important particular standards of cleanliness are. In effect, we are suggesting the local shadow pricing of pollution by the locality.* Of course there are types of pollution and areas which extend beyond political

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*This phrase was first suggested to the author by Professor David Major of M.I.T.

jurisdictions, but this fact does not necessitate absolute national standards. Presumably problems of this sort could be ironed out through the proposed (below) mediation of our two federal superagencies. We state here that such analysis ought to be based on the implications of the environmental benefit-cost approach to be discussed below.

Once standards for resource tradeoffs have been determined at the level of stage 1, then the job remains for their application in the licensing of power plant location and design. While standards are a necessary condition for efficient management, they are not sufficient. Guidelines concerning their application, flexibility in decision-making, consistent coordination of the efforts and desires of interested parties, and the design of the decision-making bodies are all necessary factors.

Licensing of plants could be accomplished at the national, regional or state level or through any combination. In our case history we demonstrated the problems which can arise in instances of overlapping jurisdiction in the absence of standards. This society will probably develop over time a sense of area jurisdiction based on legal precedent and economic muscle. An example of the former is the court decision in the Northern States Power and Light Co. case which declared radioactivity standards to be within the exclusive jurisdiction of the federal government. An example of the latter is the expanding activity of the heavily funded EPA. However, this is a process which can easily witness another decade of inefficiency of duplication of effort and non-efficiency based competition, particularly when the issues involved are political footballs. A lot of people this author interviewed expressed the view that socially efficient regulation was in the pipeline. Of the agencies interviewed, the EPA was the regulatory agency which felt it was closest to establishing general guidelines for industry. "Coincidentally", the EPA seems to have a reputation for the greatest degree of arbitrariness. Undoubtedly, some of this feeling stems from jealousy of its power, but there may be a causal relationship between general standards and arbitrariness of attitude. Arbitrary guidelines are better than none in promoting efficiency, but they are still not nearly optimal. In addition, the adoption of arbitrary rules poses the danger of their continuation through sheer inertia. On the other hand, we feel that local inputs are useful for efficient decisions, though it is also true that state bodies are more susceptible to manipulation than federal agencies. Therefore we propose that the licensing be exercised at the state level by state "agencies" (their precise form will be discussed below) using federally devised standards as inputs in their analysis and using our proposed guidelines approach (to be discussed below). Local preferences (e.g., the importance of a certain level of cleanliness for a beach) regarding benefits and costs or physical standards could be expressed within a given interval (e.g., ±10%) around federal standards except within the area of nuclear specifications.

Because it is doubtful that we could remove power plant licensing power from the federal government, and because we want to promote regional planning, we propose that the current licensing sections of the FPC and AEC and Corps (The water dumping license power of the Corps ought to be transferred to the EPA) be combined, placed under the authority of the proposed central energy administration and Environmental Protection Administration and removed to a regional basis of administration.* We feel that it may be useful to relate research and licensing efforts, provided that there is an internal mechanism for balance (in our proposal, there is an element of competition and licensing authority is limited), in order to achieve more effective R & D through a better feel for the issues. Their combined function would be the communication of advice and standards derived from their research sections to the state licensing bodies, the drawing up of the basic formats for decision-making guidelines to be used for power plant siting, participation in state land use administration for power plants (discussed below), and the review of state licensing decisions to check consistency - but using the states' allowable variation of federal standards. Modification of the analysis could be made only by transferring the proposed plant from one state to another state where a more socially efficient site was available. Of course, such a modification would require a degree of harmony among

*The current Administration bill envisions regional licensing.

state agencies and a rate regulation scheme which would mesh with this kind of decision-making. Disagreement could be settled in suit, but the suit should be required to revolve about standards and guidelines. Another approach would be the incorporation into the directorate of the state agency of places (and voting rights) for these regional representatives.

To further facilitate intergovernmental cooperation and mutual understanding between government, industry, and the people,* each state would initiate land use hearings and legislation through which power plant sites or their criteria would be determined. Such determination would be based on a rough benefit-cost analysis of the kind to be presented below to decide on which land was the most productive as power plant sites. The incorporation of location management into the energy system will minimize the potential scope and intensity of conflict around power plant sites without the diminishing effects on efficiency of delay and without the sacrifice of additional environmental quality.

At this level of regulation and within the context of efficiency criteria as discussed here, we do agree with the concept of a licensing superagency (in our discussion presumed to be at the state level but this is not a necessary condition). Provided that the evaluation of real resource costs has been previously decided, provided that coordination of

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*People don't always oppose having power plant neighbors. The closing of Sing Sing prison in New York has stimulated the community to desire local siting of a power plant by Consolidated Edison. Source: Steven Fortino, Environmental Planning Division, Consolidated Edison Co.

all interests is promulgated through formal and informal structures (e.g., land use planning), and most importantly, provided that the superagency has guidelines on what to do and how to do it, social efficiency in the broadest sense can be improved. Before proposing operating criteria for the licensing superagency, let us explore the nature of the siting conflict.

Capacity expansion is a complex process involving considerable professional skill and an intensity of sentiment which is stronger even than its financial implications, which although recognized as the utility industry's major problem, play a secondary role in planning. We have also noted that the point of greatest visibility in this process, and therefore, the most vulnerable within the context of our legal system, is the site itself. Conflict revolves about the final site rather than the set of potential sites, primarily because the utility company does not want to publicize the location of land it might buy, since such publicity and land price are undoubtedly highly correlated. It does not want to publicize the future use of land it already owns because it feels that its ultimate legal position grows stronger as the plant approaches operation, though there is perhaps some doubt that its financial position is equivalent to its legal position.

Within the current context of traditional procedures of planning and our legal system, conflict regarding power plants can revolve only about the ultimate site itself in adversary proceedings levered on the permit process. There has been some recent movement towards informal contacts between utilities, regulatory bodies, and the public, but this author doubts that they have much value. For example, the U.S. Bureau of Sport Fisheries and Wildlife recommended to one utility company that it would not consent to the use of a particular site for any kind of power plant. Yet the utility company is strongly of the opinion that it will manage to be able to construct some sort of plant there. A future conflict may arise because for some reason there is a different interpretation of ultimate legal position. Northern States Power and Light Co. in Minnesota recently announced that it will include the inputs of a body of public citizens in its site selection procedures. This sort of approach may be promising. On the other hand, how effective (assuming there is harmony between the two parties) will this kind of decision-making structure be when the agency which grants the environmental permits--which has its own set of objectives and criteria--is not included in the process. Even if this approach does prove to be efficient in minimizing conflict, how widely will it be adopted? This author is of the opinion that few utility companies are willing to take outsiders into their system planning. The costs of a Pandora's box seem to be too high to risk. Some recent bill proposals have sought to require long advance publicity on site selection coupled with the power of eminent domain for the state regulating body (e.g., public service commission), but the mere allowance of more time in decision-making will not necessarily result in greater efficiency. Furthermore, state public service commissions are perhaps not the most potentially socially efficient executors of the power of eminent domain. In the case of California the Public Service Commission has been criticized for too much open-handedness with regard to rate increases. Its response was that generous rate increases now would prolong the interval until the next rate request. This same agency has also suggested that it become the state's superagency in the control of electric power. In 1970 FPC board member John Carver asked for the power of eminent domain to resolve construction bottlenecks. At the same time he stated that environmental supervision was unnecessary.*

Nuclear plants are most sensitive to three stages in the permit process - the construction permit (granted by the AEC; process time usually takes two years), the AEC's 1% operating permit, and the state and Corps water use permits. Prerequisite for the first license (under the Water Quality Act of 1970) are a guarantee by the state involved that it will issue a water use permit and the filing of an environmental impact statement (under NEPA of 1969 as enforced by the Calvert Cliffs decision). Fossil fuel plants are vulnerable to external interference via the water use permits required from the respective state and the Army Corps of Engineers under the Rivers and Harbors Act of 1899. The significant point is that operating

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*Environmental Reporter, June 26, 1970.

and water use permits are sought after most of the plant has already been built. Thus the adversary process is implicitly deciding not only on whether a particular site ought to be used, but also on whether a particular bundle of capital equipment ought to be used, the conditions (ultimately a temporal dimension) under which it can be used, and the cost of electricity (or possibly the cost of not having electricity).

What we want to do is to create a system which will coordinate interests so that social and private goals can be better satisfied. There are many who would disregard the needs of the latter. One "systems engineer" connected with New York City's Planning Commission stated that if power plants require 20 permits then they'll just have to conform to the requirements. This author feels that regulation ought to align itself along efficient goals, and this kind of attitude is inherently incapable of promoting coordination and efficiency. It is another form of the adversary process. For example, Con Edison and its New York environmental regulators have created a situation where it is reported that reserve capacity this summer will be about 10% of normally required reserve. This situation is not beneficial to the people of New York. On the other hand, Con Edison as a private interest isn't faring so well either.*

The system outlined in stage 1 will facilitate social efficiency and the improvement of the quality of life primarily

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*In recent debt issues, Con Ed paid 7.90% on a single A rating while Carolina Power and Light paid 7.75% on the same rating.

through its substitution of a standards' responsibility center for gross site conflict. We propose a second state of the model designed to provide specific guidelines for micro level decision-making. This part of the model assumes (from prior decisions) that market prices and regulatory standards reasonably represent real resource costs. Now the job consists of channeling this information and the needs of society and the power company into efficient regulatory structures and planning.

As indicated above, there have been scores of bills--federal and state--proposing superagencies. Generally, these bills assume that merely putting all the "experts" together at one table will resolve delay problems and improve social efficiency. We feel that the importance of the latter goal is underestimated in an overemphasis on pursuing the symptoms rather than the roots of the issue. Both objectives--and particularly the latter--can be better achieved through systematic guidelines. Before listing these guidelines, let us explore the role and structure of the licensing superagency.

Because we want the guidelines to be knowledgeably applied and because we want our superagency or "expert body" to represent real power centers, we envision its structure as consisting of the heads or their representatives of the various environmental agencies, representatives of the utility industry, the head of the rate-making body, representatives of the governor, lawyers, and experts on land use and energy technology. The members should be chosen on the basis of broad-scope management abilities rather than on purely technical ability; their agency staffs can furnish the latter quality. Regional inputs (e.g., from the New England River Basins Commission) should be accepted by the superagency.

Because the social tool of land management narrows the scope of site conflict from the question of location to the question of design and because our superagency will be given a set of guidelines and criteria by which to operate, we do not view the superagency as a potential adversary arena. We see it as a body of experts advising utilities in their system design and ultimately licensing individual power plants. Regulator comprehension of power company objectives and guidelines within the context of power system planning (a 20 to 30 year projection) is necessary in order to evaluate a particular power plant. For example, the benefits and costs of nuclear versus fossil power for one of ten plants cannot be evaluated without looking at the effects on the designs of the other nine. We believe that both company and social planning will be most efficient if left in the hands of the power companies. However, the power companies will be better off with respect to cost and risk if their decisions can be bracketed (expansion, location, design) for evaluation by the permit-granting agency rather than their engaging in a one-shot one-site all-or-none review. Although this sort of process does transfer power from the private industry to the government in the earlier states of planning, private control of expansion operations is increased at the later stages of planning through the reduction of uncertainty; in business, uncertainty bears a heavy cost.

Drawing up a body of experts representing a variety of interests still poses problems of the efficient coordination of decision-making. Each expert has his own objectives and criteria according to the objectives of that agency or interest which he represents. Even given guidelines and standards, there might still not be optimal regulation. What we shall probably end up with is the satisfying execution of a potentially optimal regulation system. However, we think that this is still a worthwhile objective.

Let us discuss the kinds of problems which can crop up in a situation of multi-agency jurisdiction. Our theoretical analysis is based on the interplay of agencies in our case history; the juxtaposition of agencies in our superagency will not necessarily (or even probably) separate their identities.

Each government agency has an objective - its (learned) view of the purpose for which it exists and receives funding. The methodologies which it uses to attain this objective(s) are in large measure the result of its evolutionary development (the governmental acts and ancestral agencies of its past) and the occupation attitude as professionals of its employees.

Unfortunately, from the agency's viewpoint, it does not have unlimited resources to carry out its presumed function. It does have a budget constraint. Because the agency is not profit- or cost-oriented (only one of the agency people this author interviewed was keenly aware of investigative and administrative costs, but he didn't know what to do about them), this budget is viewed more in terms of man-hours and the stock of influence. Because of this limitation on its functioning, the agency must devise operational criteria by which it will allocate its effort. Whether or not the personnel hierarchy of an environmental agency realize that there is an internal shadow pricing of their work, this is the actual situation. It is, we think, self-contradictory for an agency to deny the useful possibilities of benefit-cost analysis (as many have done) of its regulatory behavior when in fact there are conscious tradeoffs of effort by that agency in its funcitoning. It is unfortunate that the agency does not realize these "tradeoffs" in precisely that term.

The tradeoff prices (relative weights) used by the environmental agencies for allocating their effort can be theoretically established on the following bases:

1) size of project to be regulated - in dollars or things (whichever is the most obvious measurement unit)

2) evaluation of project impact - in dollars or things

3) political reverberations (especially in the budget process) of the projects on the agency's influence

4) items one to three weighted by uncertainty - if results are esteemed by the agency as the true measure of its worth

5) time deadline

On an a priori basis it seems that a new agency or one overburdened with work (as all the environmental agencies seem to be) would rely on criteria (5) and (3) for screening future effort and scheduling monitoring activity. We reject criterion (1) on the basis of this author's work experience in government. Agencies are notoriously unconcerned with social efficiency-effort per dollar. Although some interviewees claimed that they used the second criterion, we feel that detailed evaluation of the impact of all projects would require too much effort and would be beyond the present state of the art. In any case, since impact is usually evaluated by the license applicant and subsequently reviewed by the agency, there is probably limited confidence in the evaluation; it is probably viewed as the minimal rather than the expected impact. More importantly, impact analysis as currently practiced is merely descriptive; it is a detailed list of species and not an evaluative instrument.

At the agency decision-maker level we think that decisions as to favored areas of activity would include the fourth criterion as well as (5) and (3). Utilization of the fourth criterion would require a sagacity which comes of experience or ambition. It would certainly not be used by lower level employees because of the necessity of having an overall view and the leisure to plan that this criterion involves. Professional chauvinism, poor leadership or extended hierarchies of decision-making could block out the balance required to construct decisions around (4), leaving the third and fifth criteria as the only determinants of agency policy (especially at the regional or sub-regional office level). We have a concern for the fourth criterion because we think its presence is a useful prerequisite for our proposals in improving management. The fourth criterion is the closest of the five to establishing conscious tradeoffs of resources.

Note that a potential basis for intra-agency delay is introduced by the possibilities of different decision-making criteria being employed at different levels of the hierarchy for the evaluation of the same project job.

There are several large problems at the interagency level(s) of coordination. One is that different agencies (Recall that under NEPA even the preservation of historical landmarks requires appropriate consultation.) may have congruent objectives. For example, in the case history the EPA wanted to use a mixing zone rule and the state agency wanted to use a rule based on coolant outflow to regulate temperature. A question of agency ego and professional competence then enters the picture. The result is delay. When the advisory and licensing agencies have non-conflicting technical criteria for achieving the same or different objectives, then a priori, there is no problem of delay. However, given the complex nature of environmental problems, it is quite likely that the proposed technical criteria cannot be simultaneously attained because of an inherent conflict between their implementation or their objectives within the limited area of geographic impact of the project. The technical agency people who proposed the criteria did not have to seriously consider this problem in their initial investigations. But the final decision-makers must. A delay can result as further consultation proceeds. Again, questions of agency ego, agency political weight, and personal professional competance come into play. The outcome, aside from containing the delay problem, may even finally be that the environment is not served best because of the distribution of political weight among the agencies and legal technicalities. Conflicts within and between agencies can be settled by hierarchical decision-making. Problems arising here are: the decision volume may overload the rather personal nature of this style of solution, causing inefficiencies of action or delay; dissatisfied advisors, coming to the assistance of intervening private individuals or other agencies, may appeal to upper decision-maker levels and the courts for reversals of decisions. (This problem did crop up in our case history.)

The remaining case--and one which we think unlikely as a condidate for the "general case"--is when the various agencies come up with regulatory environmental standards which do not conflict at all - either at the theoretical technical measurement level or in terms of their implementation. Aside from sheer bureaucratic delay, we don't see any managerial problem of agency coordination here, but we do see a looming problem of whether social efficiency is really being served. This problem is directly related to the roots of the difficulties of the other administrative cases and the general problem of social decision-making - there are no explicit economic standards on which to base regulatory standards. Not only does the whole system operate inefficiently, but because of the absence of a common decision-making perspective it is even incapable of learning how to operate more efficiently.

Theoretically, the basis of justification for regulation is the maximization of some concept of social welfare. Since regulation is performed by regulators, the implementation of this concept is tinged with private interests and constrained by the attitudes and abilities of the agencies' managers. As we have previously discussed, regulation can be a difficult art. It would be a conceptual error to treat it as a scientific discipline or as potentially enlightened despotism. Therefore our scheme for social management is the description of a flexible approach including some emphasis on the "how to do it"; we feel that the mere statement of "what to do" would fall short of the ethical necessity of accepting the problem as our own.

Direct regulation of the utility industry has three dimensions - rates, environment, and accounting. Within the context of the utility industry, rate regulation is theoretically supposed to give back to the people some of the profits of a naturally monopolistic industry in the form of lower electricity rates. Environmental regulation is theoretically supposed to protect society from unnecessary spill-over resource costs.

Essentially, regulation provides coverage of taxes, depreciation, and operating expenses. These expenses are paid out of working capital and holdings of short-term securities; the former is the ready cash which must be kept in the till to accommodate unexpected expenditures until revenues can come in (the time differential is about a month). Short-term securities earn the market rate-of-return. Working capital represents an opportunity cost (of not investing the money); therefore the rate regulators allow the regulated rate of return on investment (ROI) for working capital. This rate of return is based on the cost of raising capital--equity and debt--to meet operating and expansion needs and is applied to net assets as well. When ROI - k_o, then the company's market valuation is constant (all noise-factors assumed away).

This general regulation scheme offers no direct incentive for operating efficiency - all expenses are covered. There is an indirect incentive in that except for working capital and the immediate positive cash-flow effect of expensing deductions from income tax there is no profitability (ROI) in running high expenses. The scheme also encourages--within the limits of the financing constraints--asset accumulation in that an increase in assets means a larger rate base. When the cost of capital to finance such an increase is less than the expected future rate of return and under the conditions of expected economies of scale there is a strong incentive to maximize assets. When the cost of capital is above the expected future rate of return, then there is a strong disincentive to increase fixed investment. In the past the former case has usually prevailed.

Within the context of financial constraints (e.g., required interest coverage) uncertainty as to the lag time of regulatory decisions will be a negative incentive to expansion. The FPC generally takes less than a half year to decide on cases, but state regulatory bodies (which adjudicate the great majority of rate hearings) often take much longer. The edicts of the Price Commission also resulted in an unexpected lag in rate increases. One of the effects of that body may be a shift to slower capacity expansion. If meeting projected load demand is a good thing, then this is a negative effect on social welfare.

If there are differential levels of uncertainty concerning the rate regulators' acceptance of cost items into expenses versus assets, then there will be corresponding shifts of new dollars in the direction of these accounts.

Thus far in our discussion of the incentive implications of rate regulation we have been speaking as if a utility system were as flexible as cash. Of course, it isn't. However, different cost patterns do underly alternative systems of equivalent capacity; there is a potential mix of generating equipment - nuclear, steam, hydro (including pumped storage), and internal combustion. Paradoxically, instead of planning systems with the objective of maximizing profit, the utilities have been doing largely what is more the regulators' responsibility - maximizing social welfare by planning the system of lowest cost (although, as we have pointed out, current cost projections inadequately treat a lot of important factors). This author is puzzled by this paradox and can conceive of three possible explanations: (1) The utilities haven't though about profitability.(2) Minimizing cost minimizes the electric bill, which is so important as a lever for rate increases to cover the cost of capital that it becomes the key objective. However, we don't see that this argument leads very far; cost of capital would be covered in any case. Also, efforts directed at minimizing the electric bill will also tend to yield a competitive edge over non-electric energy forms, which would increase company revenues (and assuming economies of scale, profits too). (3) The utilities do realize that profitability is enhanced by the superior contribution to the rate base of nuclear investment, and the minimum present value technique is just another, more publicly acceptable argument for building nuclear plants. This latter case is doubtful because there are too many people "in on the secret".

Rate regulation ought to align its incentives to promote social welfare, though problems in motivating behavior can arise when response to reward is paradoxical. However, it is imperative to recognize that regulation includes more than rate fixing. Depreciation policy can be guided to correspond to environmental and rate objectives because of depreciation's powerful effect on cash flow. The removal of accelerated depreciation would probably slow down the growth of the industry. Accelerated depreciation for pollution abatement equipment would facilitate the use of such equipment. Industrial-revenue bonds, whereby a company leases a facility built to its specifications by the municipality at the municipality's cost of capital (which because of the tax deductability of governments is lower than that of private companies) can also play a role in the financing of anti-pollution equipment* and of thermal treatment-recreational facilities, provided that the utility is not penalized by the deletion from profitability of the lease payments to the municipality (currently, leased facilities are not allowed to enter the rate base).

We have already reviewed administrative problems in environmental regulation. Therefore we will only stress once again the importance of consistency in depreciation-rate-environmental regulation.

Section 5 - Guidelines for Stage 2 Within the Context of Social Welfare Analysis

Having discussed the role of regulation and its appropriate structuring, let us now examine guidelines for our proposed regulatory superagency to use in its assessment of power systems and power plant planning.

The objective of the regulatory body is to maximize social welfare. We can view social welfare as a function of national

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*There have been two announcements of this kind of financing. The one closest to realization is the agreement between Hillsborough County Industrial Development Authority and Tampa Electric Co. which is expected to save the company around $10 million over a 35-year period.

income and environmental quality. Social welfare is improved if one or both of these factors is increased and neither is decreased. Social welfare is decreased if both of its components decrease or if one decreased and the other remains fixed. Difficulty evaluating social welfare is found when one factor is increased and the other is diminished. Given a world of limited resources, this last kind of situation is probably the most common, though we also argue that better social and private management could cut delay costs* which would not diminish environmental quality and which would increase national income through the more efficient utilization of resources. Enhancement of environmental quality without a decrease from the original level of national income is also possible through the tradeoff of part or all of the consequent increase in national income. An increase in environmental quality without a loss of income is also probably possible through more efficient laws and regulatory structures. For example, an Ohio law originally intended to discourage prostitution is now being applied against the "public nuisance" of pollution. Another example is our case history where it seems that although air pollution is a major complaint, a water pollution case has been prepared because it is currently easier to fight water pollution in the courts than air pollution. It is doubtful that such indirect regulation is

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*See pages106-107and then page103 for a description of delay costs.

efficient in the long run, even within the dimensions of environmental quality.

Symbolically, we can think of the social welfare function as

$W = f(I) + g(E)$ where I = national income, E = national environmental quality

Without eliminating relevance, we can simplify this expression to

$$W = I + g(E).$$

Here we assume that the marginal social utility of income is constant.

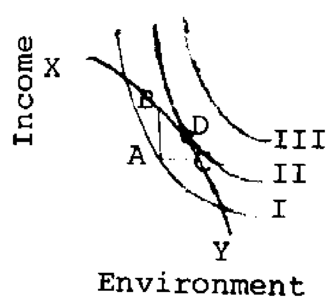
Because of limited resources, tradeoffs between national income and environmental quality must often be made under the conditions of physical growth. The Industrial Age has its price. The function of regulation ought to be to ensure that the price is what society wants it to be and to ensure positive conditions for potential growth. (The argument of the necessity of zero economic growth is often heard, but few have attempted to eat it.) Basically, this means that regulation consists of decision-making on the basis of

$W = I + \lambda g(E)$ where λ is the marginal tradeoff between income and environmental quality.

The proper role of power plant regulation is to determine a value(s) of λ based on what society wants so that "W" can be maximized.

Society also accepts the role of influencing the distribution of "I" and "g(E)". It need not be the function of a power plant licensing body to determine the ultimate distribution of income. This task can be left to Congress. If there is a net increase of "I" then that increase can be apportioned in any way society wants. Nevertheless we suggest that this consideration be taken into account at the federal level in the allocative funding of research and development because it is too easy to take an important issue and say "that's not my problem" and promptly deposit it in someone else's backyard. Of course we still haven't tackled the issue here, but we do want to state that it exists and should be an input to federal regulation, the coordination of regional planning, any future development of regulations concerning pricing of electricity, and site location. Another issue of at least equivalent weight is the distribution of $\Delta g(E)$. Power plants have an intensive environmental impact and therefore must be attuned to the needs of the people who are going to be affected. (We have already discussed this problem in greater detail.)

Graphically, the welfare function issue is



Arc XY defines the production frontier of income and environment given our current state of technology. (While environment is not a product like a widget, there is very little of it still in its "natural" state, which state is not fixed over time anyway. Thus our environment can be considered a product of the way we allocate our resources.) It is our thesis that we are currently on indifference curve I. The area of section BAC represents the potential for increase in social welfare through more "I" and/or more "g(E)". Better management within each dimension (e.g., more efficient application of current energy technology and more effective environmental laws) means an advance into this sector along $\overline{AB}$ or $\overline{AC}$. Better management between dimensions means that society is giving up that amount in one dimension which is at most equivalent to the gain in the other dimension. Reaching the highest level of welfare within society's resource and technological constraints--point "D" on the production frontier "XY" and indifference curve II---means that the proper λ has been selected and successfully utilized in decision-making. λ is a measure of relative willingness to pay in terms of tradeoffs of income and environmental quality. λ is the slope of society's indifference curve. In welfare economics point "D" is known as the point of Pareto optimality. It can be reached only when all resources are used efficiently - when they are fully utilized to promote society's goals. If society is unhappy with the distribution of resources, then it can still reach maximum social welfare through redistribution of the slices of this largest possible welfare pie.

At this junction the crucial issue is the measurement of "g(E)". We could take the traditional economists' viewpoint that the actual tradeoff decisions lie in other spheres of responsibility; however, let us note that the measurement unit of "g(E)" is a necessary attitudinal and informational influence on tradeoffs (the determination of the parameter λ based on it.

Some environmental impact guidelines use the population of each affected species as the unit of measurement. This kind of measurement prohibits objective planning beyond the elementary and inflexible objective of "don't kill". Others attempt to derive environmental indexes from diversity and population of species. Major problems here are the integration of land and air indexes with the more easily definable water quality index and the non-linearity of marginal environmental changes - these are coupling effects.

Complex environmental issues usually involve environmental interactions within and among the three divisions of the environment - land, air, and water. Any systematic evaluation of tradeoffs between power plant design and environmental impact must be made with the understanding that each of these divisions of the environment has its social cost curve with respect to pollution and that tradeoffs can be made between these divisions as well as between environment and income. $g(E) = h(A,L,W)$ where A is the air dimension, L is the land dimension, and W is the water dimension.

For purposes of clarity and flexibility, we believe in the use of the principle of the willingness to pay of society as an index of environmental quality - i.e., our proposed unit of measurement is the dollar whenever possible (in which case $\lambda = 1$). Species population counts and environmental indexes can be translated into willingness to pay, but we feel that in themselves they are currently inadequate to facilitating social planning. It is our thesis that things have no intrinsic value. They are valuable insofar as people value them. If the proverbial tree falls in the forest and nobody hears it fall, then it didn't fall. Of course, someone could come across that fallen tree years later and observe that it did fall, in which case we base our concept of willingness to pay on current usage and probability of future usage. The concept of willingness to pay is unfortunately not an end to the problem of measuring "g(E)". Willingness to pay can be determined within any of a theoretically infinite number of geographic boundaries (whose willingness to pay?) through the application of market prices, surveys, and regulatory fiat. Under competitive conditions and no spillover costs (e.g., my detergent ruins your well-water) market prices represent a reasonably fair measure of willingness to pay. Problems arise in its use when either of these two assumptions is relaxed or if there is no market for a particular good (e.g., aesthetics) or if the distribution of income is unfair. Problems generic to the concept of willingness to pay rather than just its market valuation are misinformed consumers (which problem is closely related to that of spillover costs) and the possible under-representation of future generations in consumers' welfare functions. Surveys of willingness to pay can correct for the absence of the assumptions of competition and equity of income distribution. If they are worded properly, they can also help correct for the distortion of the relationship between social welfare and willingness to pay caused by misinformed consumers. Surveys' disadvantage is that their application to individuals who will not bear the costs of their preferences can distort valuation. The larger the area of the survey, the greater is the potential for this kind of effect. Regulatory fiat can correct for all of these problems but it also creates the potential of the even greater one of bureaucratically inflexible distortion of evaluation.

It should be clear that there is no one best approach to measuring willingness to pay. A flexible and experimental approach is required to strike an efficient balance between its methods of determination. Our guidelines for environmental costing will suggest a priori reasonable methods, but we expect that they can be improved upon.

For purposes of illustration of the principle of willingness to pay in social welfare decision-making, let us apply it at the simple marginal level of one tree. Assume that it is proposed that a "local" tree be removed and replaced by a bus queue shelter. We want to determine the net effect of this action on society's welfare in order to arrive at a justifiable decision regarding the proposal. Furthermore, we want to use our analysis to derive useful directions of alternative approaches to the allocation of the involved resources according to potential effects on social welfare.

Suppose that a survey is taken of the local community in which the population of 100 indicates that the value to it of the shelter is $5/person. Then the social welfare value of the project is $500. (Public goods have additive utility.) Note that if it is known that the state and not the locality is going to be footing the bill, then valuation and willingness to pay survey may be ballparks apart.

If each of these 100 people thinks that the tree is worth $1, then its social value is $100. The assumption of an equitable distribution of income underlies in part (if an actual payment is related to willingness to pay) the connotations of this figure. $100 from the citizens of Roxbury is more weighty in the state of society's well-being than $100 from the citizens of Beverly Hills. We could correct for this situation by denoting a function f(I) dependent on assumptions of the marginal utility of income. We could also correct in part for this problem through the use of national standards of the value of a tree. (There could be a set of values and guidelines as to their application.)

One potential complication arises when 1,000,000 people all over the country (or indeed in China) say that they also value the tree in their social welfare function. Again, the principle of willingness to pay can break down in a survey situation when the interviewees are not subject to the costs and benefits of local decisions. The substitution of competitive market prices (i.e., the cost of the tree's replacement) can prevent the development of this sort of dilemma. Another approach would be simply the control of the survey handout.

Another problem may be that the $100 valuation of the tree represents an uninformed valuation. To help correct for misguided valuation the tree can be broken down into its functional elements and then each element evaluated:

1) protection of soil
2) shade
3) aesthetics
4) home for birds
5) fruit growing

Elements (1) and (5) can be evaluated via market prices of replacement and purchase. Elements (2), (3) and (4) can be analyzed through surveyed willingness to pay. The weights in the decision of these latter elements can be analyzed via sensitivity analysis. If these latter elements are shown to have a major impact on the decision, then attention can be given toward the alternative of putting the bus shelter elsewhere (or even of putting in a street-light instead if it becomes recognized that that is what the community really wants.)

In our illustration analysis so far we have neglected several key factors of the decision. One is its time horizon.

The bus shelter and the tree have values for usage now and in the future. We can compare their effects on social welfare only in terms of the present values of these usages to society. Perpetual valuations of \$500/year and \$100/year respectively, discounted at "the social rate of discount," e.g., .05 (the time value of money) would yield

present values

benefits of shelter $$\sum_{t=1}^{\infty} \frac{\$500}{(1 + .05)^t} = \frac{\$500}{.05} = \$10,000$$

disbenefits of lost tree $$\sum_{t=1}^{\infty} \frac{\$500}{(1 + .05)^t} = \frac{\$100}{.05} = \$2,000$$

The net change in social welfare is +\$8,000.

If a park is expected to be built in the neighborhood of the tree, then the tree will acquire a lower present value. If the bus route is experimental then its present value will also be lower because of the risk of no future value. Thus evaluation of social welfare functions must take time and uncertainty into account. If the population of the community is expected to vary in the future then both of the present values will also change. If the area has no current population but is expected to have a population of 100 in the next year and perpetually thereafter then the present value calculations are

benefits of shelter

$$\sum_{t=2}^{\infty} \frac{\$500}{(1 + .05)^t} = \$10,000 - \frac{\$500}{(1 + .05)^1} \approx \$9,500$$

disbenefits of lost tree

$$\sum_{t=2}^{\infty} \frac{500}{(1 + .05)^t} = \$2,000 - \frac{\$100}{(1 + .05)^1} \simeq \$1,900$$

The net benefit to society is now $7,600.

Note that the tree's functions of soil and animal protection could give it value during the first year, even though no people are living in the area. Thus the loss of the tree one year earlier than the point the decision need be made would have a larger negative impact on social welfare than its removal one year later when the decision must be made.

Another key factor is that we are interested in evaluating net present values - present values of projects less the resource costs of investment and operations. The net present value calculation for our illustration is:

$$\Delta W = B_S - I_S - O_S - B_T + O_T + S_T$$

where ΔW = change in social welfare

B_S = benefits accruing to society from shelter

I_S = cost of building shelter

O_S = cost of maintaining shelter

B_T = lost benefits stemming from tree

O_T = cost of maintaining tree

S_T = salvage value of tree

All measurements are in present value terms.

All of these variables--except elements of B_T--are essentially income variables. (B_T is partly an environmental quality variable.) At least part of B_T (beyond the value of produce) can be expressed in fairly precise economic terms. Intervals of values can be specified for the evaluation of uncertain costs and benefits. The best decision is that which maximizes $+\Delta W$.

Summarizing within the context of the electric utility industry, we feel that power plant siting ought to maximize the present value of

$$\Delta W = \Delta I + \lambda \Delta g(E)$$

where $\lambda = 1$ when $g(E)$ is expressed in dollars.

$$\Delta I = R_j - I_j - O_j - S_{jE}$$

$$\Delta g(E) = E_{jB} - E_{jc}$$

R_j = benefits of electric power production of jth alternative project

I_j = required investment of jth alternative project, including provisions for environmental enhancement

O_j = operating costs of jth alternative project, including provisions for environmental enhancement

S_{jE} = net income effects of a change in environmental quality caused by jth alternative project

E_{jB} = benefits accruing to environmental quality caused by jth alternative project

E_{jC} = explicit costs in dollars and any intangible quality of life from pollution caused by jth alternative project

All measurements are in present value terms. Costs are expressed in positive numbers. I_j and O_j present little difficulty in measurement. R_j does present problems because the electric utility industry is a licensed monopoly. S_j is a net figure because the unemployment of, e.g., one fishing boat in a particular area does not mean that it and its operators will not obtain employment elsewhere. E_{jC} and E_{jB} present the kinds of problems that we discussed in our example. Note that the inclusion of a term for environmental benefits from power plant siting indicates a positive role for regulation rather than the current "sit on it" role. We envision this positive role to be centered around the utilization of waste heat, which would have impact on S_{jE} and E_{jB}.

The utilization of waste heat is a potential means for compensating a locale for the difference in its pre-plant and post-plant social welfare levels and as a means of turning an opportunity cost (value of the unused heat) into a profit for both society and business.

Currently, there are four major categories of suggestions for the use of the low grade heat source available from the heated coolant outflow. They are: heating for greenhouses, sewage treatment, recreation (bathing and sport fishing) and aquaculture. We will only briefly summarize the arguments for the last.

Aquaculture is the raising of sea life through man-made changes in the sea environment. The Orientals have been doing it for hundreds of years. Aquaculture can be extensive or intensive. The latter approach requires greater technology and labor costs, though the capital cost/fish is low because of the extremely high yield per unit volume. The largest cost is usually the food supply.

Many fish thrive in water heated slightly above ambient conditions of their natural environment. Their maturation period decreases and they may even grow to surpass normal adult size. If the negative effects of thermal effluent (mentioned earlier) can be avoided by extra capital investment, then the venture could produce positive net benefits for both income and environmental quality. Even now, oysters are being raised in the thermal effluent of a power plant in Northport, Long Island, for commercial sale. Their maturation period has been decreased from 5 to 2-1/2 years. There are numerous factors which go into a decision about what species to do aquaculture on. These include adaptability to temperature range, local pollutants, and market conditions.

Although no one seems to actively oppose aquaculture using thermal effluent, there is very little effort being put into the development of aquaculture as an industry in this country, whether thermal effluent is used or not. One reason is this country's historical attitude that the coastal waters belong to the public. This attitude bears large responsibility for the decline of our fishing fleet. Another reason is that it seems to be no interest group's objective to push aquaculture. The regulatory agencies are interested in environmental preservation; the utility industry is interested in producing power; the affected community probably never heard of aquaculture; entrepreneurs fear the uncertainty associated with a new industry maintaining property inputs to portions of water bodies and government regulation. Aquaculture will not come of itself. One of these groups is going to have to initiate it. In Maine it may be the government. In New York, it is an entrepreneur.

The remaining tasksof this chapter are the measurement of R_j, the itemization of E_{jC}, and the structuring of our discussion of social welfare into the stage 1 - stage 2 framework of decision-making.

The first decision that a permit superagency ought to make is whether additional capacity is needed, and if so, how much. This decision assumes a socially acceptable reliability index. While such a decision can be made only on a plant by plant basis, there must be a liaison between the system planning of the company and the agency to facilitate efficient administration by each side. We discussed this point above. We suggest a general tentative permit for system design which would be based on the superagency's guidelines regarding E_{jC} (discussed below) and the projected net benefits of the system. The benefits of additional capacity are really the costs of not having enough electricity. These include voltage cuts which impair the efficiency of motors, the cutoff of manufacturer interruptables, brownouts, and ultimately system failure. These costs can be decreased if the power failure can be anticipated. There is no good reason why an analysis of these costs could not be undertaken by our proposed central energy administration.

Rather than examining the cost of not meeting projected demand, many benefit-cost guidelines (e.g., that of the AEC) regard the projected revenues (sometimes gross, which is definitely incorrect, and sometimes net) of the power plant as a real measure of the benefits accruing to its construction and operation. Some utility people consider this a minimum estimate because of the place of electricity in our economy and the structure of rate regulation. Some environmentalists consider this a maximum estimate because they claim supply (of electricity) creates its own demand and because the utilities are a monopoly. At the marginal level of expansion rather than at a level of the contrast of the alternative states of no electricity vs. enough electricity, electric power does have a marginal value. The same kind of argument applies to air. Revenues net of taxes--R_j--is probably a good proxy of the willingness to pay for the resources which are used to produce electricity. (However, insofar as taxes represent a charge for marginal costs of the power plant imposed on the local government, that element ought to be included.)

Capacity can be increased in two ways - through construction and purchase. Given the contingent S_{jE} and E_{jB} and E_{jC}, the mix of sub-alternatives of the former alternative can be evaluated. I_j can be adjusted downward through the shadow pricing of construction labor if there is unusually high unemployment of construction labor resources and if these otherwise unemployed resources would be utilized in the project. A federal council of economists could decide on the applicability of the shadow (real resource) price of such labor. The reason that the shadow price might be lower than its market price is that there are price "imperfections" in the construction labor market such that wages do not fall with demand and consequently price does not reflect the utilization of this resource.

Consideration of the purchase alternative involves several problems. One is that current rate structures do not allow a ROI on purchased electricity - it is treated as an expense. Thus this aspect of rate regulation would have to be altered to increase the flexibility and efficiency of system planning. Pooling--a modification of purchasing--can also be arranged, as demonstrated by NEPOOL. Pooling can be encouraged through rate incentives based on its marginal benefits to society and the utility companies.

Other problems concerning purchase arrangements are that there may not be enough surplus capacity in neighboring systems (Perhaps there should be if there are more efficient sites in the neighboring areas.) and that the determination of E_{jC} (and E_{jB}) may lie in the jurisdiction of another superagency. An approach to these problems can be facilitated through the mediation between the superagencies by the proposed federal regional agency. We admit that it would be a complicated process, but its complexity would not extend much beyond our guidelines and so is not impossible.

We have indicated that there is a mix of alternative system designs for satisfying any given capacity requirements. However, the system design and its locational matrix (Recall that our system includes a legislated set of efficient sites.)

and more especially the design and location of a single plant (in which case the decision has already been made as to whether it is base or peak, nuclear or fossil) are far from infinite in number. The consideration of alternatives in our system does lie within current technical constraints.

Current system design is most sensitive (and sensitivity does not seem to vary more than ±10%*) to foundation (particularly for nuclear plants), transmission, cooling system, and land cost differentials. Within a given hundred-mile radius transmission differentials are insignificant. In Chapter V we discussed the inadequacies of this planning from the utility management point of view. From the social viewpoint, such planning accounts for only part of the national social welfare; S_{jE} and E_{jC} must also be included. We propose the use of the function presented on page 97. Insofar as taxes do not represent payment for government-provided services and goods, they represent a redistribution of income and not an increase in national income. Thus, most taxes would be subtracted from revenues, R_j, in order to determine the benefits of the additional power. A community council ought to be set up by the superagency to make arrangements to compensate those who directly bear the costs of the power plant's negative spillover effects.

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*New England Power Pool, op. cit.

The costing of environmental impact (both negative and positive) should be based on standards determined by the EPA. Local preference is to be given some leeway. Standards can be based on market prices, willingness to pay surveys, and regulatory fiat based on research. The basis of application of all of these approaches should be current usage and the probability of future usage. Uncertainty can be treated through sensitivity analysis over a range of dollar values. Intangibles should be made explicit. Delays of decision-making on licenses in the hopes of improved technology should be evaluated through an assessment of probable future benefits and the costs of the danger of not having enough electricity and the consequent overworking of older and dirtier equipment (whose marginal cost of operation can be four times as high as operating cost under normal load conditions). The following table lists the items of environmental quality which are closely affected by power plants. Listing is by dimension of environmental impact. Measurement bases for tradeoffs are also indicated.

Section 6 - The Itemization and Evaluation of E_B and E_C

Environmental Dimension	Kind of Impact	Evaluation of Impact
I water	1) commercial harvesting (e.g., fish, Irish moss) of the water body (as affected by thermal effluent, entrainment, biocides, and oil spills [if oil plant]; include effects of aquaculture)	net present market value of probable affected commercial harvest over life of plant (net of costs) plus net present value of affected expected post-power plant commercial usage or the present value of the restoration of the water body to its natural state, whichever is lower.
	2) non-commercially valuable sealife (aesthetics)	same as (1) except present value is based on non-market measures of willingness-to-pay (e.g., surveys, regulatory fiat); an interval rather than one specific value can be used
	3) corrosion of property (from action of heavy metals in coolant outflow)	present value of cost of repair or replacement, whichever is less
	4) bathing effect (from fly ash deposits on water surface, oil spills, and heating; include development of recreational facilities)	present value of bathing over affected time horizon based on willingness to pay for usage, which would be proportional to population density (this can be a positive figure if the bathing season is extended) or (in the case of negative effects) replacement (of beach) cost, whichever is less

Environmental Dimension	Kind of Impact	Evaluation of Impact
(I water)	5) appearance of cooling system (aesthetics)	present value of willingness to pay determined by survey and/or regulatory fiat to avoid alternative appearances; these values (or intervals of values) would be relative to population density and the existing aesthetics level of the surrounding environment
	6) drinking water effect (either directly affected by coolant requirements or by saltwater [if saltwater is coolant] effects on water table)	market or surveyed or regulatory valuation of water supply in present value terms
	7) other	probabilistic present values over related time horizons
II land	1) appearance of plant design and landscaping (aesthetics)	see I-5
	2) fogging: land traffic, air traffic, sea traffic	present value of compensating for to maintain safety; would be based on regulating fiat and/or market prices.
	3) light and noise* pollution (both from plant and, if present, from cooling tower	present value based on survey of willingness to pay to avoid such pollution; would be relative to population density and existing level of such pollution in the surrounding environment

*Currently the constraints on noise pollution derived from occupational safety laws are the limiting regulations for power plants. Source: Mr. Frank Ritchings, vice-president, Ebasco.

Environmental Dimension	Kind of Impact	Evaluation of Impact
(II land)	4) change in value of land and its products caused by power plant siting - destruction of its quality (e.g., effects on local produce of air pollution or the agricultural utilization of waste heat, and, if there is a cooling tower, from icing; use of land as a leaching field or for fly ash disposal); change in neighboring land values due to "neighborhood effect"	present value of changes in market prices for the land, which presumably reflects the changes in its perceived productivity
	5) other	probabilistic present values over related time horizons
III air*	1) health of people and animals (as affected by NO_x, SO_2, and particulates)	present value of surveyed willingness to pay; would be proportional to population density*
	2) corrosive effects on physical property of air emissions	present value based on market prices of repair or replacement of personal property, whichever is less
	3) other	probabilistic present values over related time horizons

We have not included benefit-cost work for nuclear plants because such analysis is more properly within the jurisdiction of a national agency rather than a regional or state licensing superagency. However, similar analysis can be (and is) utilized on that level. We suggest that such analysis also include adequate costing of the treatment of radioactive waste.

*For the present time, air pollution standards can probably be more efficiently based on the marginal costs of alternative "reasonable" standards.

CHAPTER VII

APPLICATION OF ANALYSIS TO THE CASE HISTORY

Relating our analysis to the case history is complicated by the fact that the case is sensitive to publicity because it has not yet been decided. Therefore much information is confidential from the viewpoints of the interviewees and this author. Most of the issues and data discussed in this paper were not cheerfully volunteered public information. Another problem is simply that many of the numbers are lacking, since the actors of the case have not been conducting it within our proposed framework. Nevertheless we will apply our kind of analysis to the dimensions of thermal pollution and entrainment. While it is true that the objective of maximizing social welfare includes other dimensions of the environment, and that thermal standards might be affected by cross-effects from these other dimensions, we are not equally knowledgeable re Brayton Point to properly analyze other dimensions of pollution there.

Thus far, the proposed environmental modifications for the thermal problem (There seems to be an acknowledgement that the entrainment problem can be solved only partially.) and the entrainment problem would cost the utility company somewhat less than $8,000,000 in capital investment. The two-year delay in construction while negotiations have been going on has cost the company $10,000,000 to $15,000,000 in inflation cost, chiefly from construction labor increases.

Excess interest on the extended construction has probably amounted to something under $1,000,000. The increased cost of the facility and delay in expected revenues and several other factors of the business environment have combined to strain the company's coverage problems now and for the immediate future, although the decrease in long-term interest rates during most of this period of delay has served to counteract at least part of this problem. (The company goes out to borrow long-term money only when the power plant is mostly completed.)

The utility's profitability and business position and ultimately its market valuation is influenced by the above factors relating to interest costs and by the differential marginal costs of producing electricity in an efficient, new facility versus getting the power by overworking older capacity and/or purchasing. (Recall that there is no profit allowed on purchase.) After some costly lag, most of these increased costs will eventually be passed on to consumers in the form of higher electricity rates; this increase, however, will not be high enough to serve as a rationing mechanism for power. Thus the costs associated with delay and that part of environmental cost which is inefficient do not benefit anyone.

Part of the cost of delay is a decrease in environmental quality resulting from the use of older and dirtier facilities. In the dimension of environmental costs the environmental agencies are trading off lost environmental benefits now (assuming that some compromise agreement could be reached now) for future environmental benefits gained from the tougher standards expected to issue from a tough stand.

The approach to these problems can be bracketed into three game functions for decision-making. One is that of social regulation, which ought to be doing a benefit-cost analysis of the kind presented in Chapter VI (see page100). Tradeoffs between national income and the more intangible elements of environmental quality (The tangible ones are readily translated into national income; e.g., the value of a bathing beach) ought to be determined for various standards in order to arrive at the optimal improvement of social welfare.

The second function is more clearly a game function. The regulators ought to evaluate the costs of standards and delay on the company's profits in order to determine its indifference function to environmental regulation. For example, the company may be willing to spend $7,000,000 now for environmental modifications rather than $12,000,000 next year for $6,000,000 worth of environmental modifications and $6,000,000 worth of delay costs. If the utility company hasn't figured this out, then it is the responsibility of the regulators, if they are not indifferent to implications for national income, to point out such relationships.

The third function is one for the utility company. It should evaluate the net present values of alternative decisions and their implications over time. It should be making decisions based on an arsenal of quantitative knowledge of the ramifications of environmental negotiations on its power system.

We will illustrate game function one with respect to the thermal and entrainmtnt problems. Function two is based on both one and three, and detailed analysis of the third function is reserved for a later paper.

1) The first question to ask is whether additional capacity is required. This could be determined by ascertaining the probable impact on New England of 465 mw loss of electric power than planned. This would mean more frequent voltage drops, brownouts, and increased danger of system failure. It would mean higher electric bills because older and less efficient machinery was being used. A proxy of expected revenues (net of taxes) could be substituted for these calculations. This figure should then be composed against the present value of engineering and environmental costs of a set of efficient-looking locations (discussed in section 5 of Chapter VI). Modifications could be made at each location to determine sets of sub-alternative designs. The fact that some investment has already been made at Brayton Point should be disregarded in this analysis; it is a sunk cost. The purchase alternative could be evaluated,but at the present time this is not

really an operational concept because the additional capacity is too large for neighbors to supply and because the rate regulation scheme is inefficient.

Let us assume that the additional capacity is required, that its most efficient location is at Brayton Point, and that R_j has been calculated as an input into national efficiency; then the following analysis should be made.

2) Investment for thermal abatement facilities (the diversion channel and spray modules) is made in part to prevent the killing of commercially and aesthetically valuable fish, whether they are caught or appreciated in Mount Hope Bay or only feed and spawn in the estuary there and are caught or appreciated elsewhere. There seems to be little evidence of thermal damage related to the power plant. Perhaps a threshhold has just not yet been reached. A range of present values of social cost ought to be calculated (see 6.6) based on a current projection and a worst case. The discount rate which is used in the present value calculations could be the company's cost of capital or some social discount rate based on an averaging of the rates of Treasury bonds. Undoubtedly the company would base its arguments on its rate and the regulators would base their arguments on their rates.

Uncertainty could be expressed either by an increase in the discount rate or a probability weighting of each possibility. The final discount rates and probability weights used could be based on a new law and/or on a negotiated outcome. In any case, the gap between the prime rate of the utility and the Treasury bond rate is small enough to contain disagreement within reasonable scope. If there is a significant danger of a large fish kill, then the possibility of a coupling effect causation ought to be investigated. If it is only the combination of chemical effluent and thermal effluent which kills fish and not thermal effluent in itself, then it may be cheaper just to control the former.

3) Bathing off South Swansea is currently spoiled by high temperatures (over 90° F) at times during the summer. The water is just too hot for some. More importantly, fly ash (from boiler cleanings) settling on the water from uncovered fly ash waste deposits and algal growth stimulated by the thermal effluent ruin the quality of the bathing.

$7,000,000 is a lot of money to spend to improve a beach which serves a small community (South Swansea is a small part of Swansea, which had a population of 10,000 in 1960.) It might well be more efficient to compensate residents based on the use of the beach and a usage value, e.g., $3/bather/day (e.g., 200 persons/day for 90 days) for the period of the water's being affected*) or to replace this beach with another one which is unaffected by the coolant outflow and then to maingain a shuttle service if necessary. The net change of property values should then be calculated and entered into the decision function.

4) The value of the fish kill due to entrainment currently seems to be under $10,000 a year. At a cost of several hundred thousand dollars,screens can be installed at the intake which can save adult fish but not plankton and fish eggs and larvae. However, the destruction of plankton (fish food) does not mean that there will be that much less plankton in the Bay. There does seem to be some dynamic ecological balance which will speed up the production of plankton to a certain level if some is killed off.** Thus it appears that the entrainment problem is barely worth the cost of the proposals; it is certainly not worth a delay.

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*See section 6.5 for a discussion of this kind of calculation. We recognize that there is a problem of what discount rate should be used. This is a problem which we have not fully dealt with here. In planning alternatives the company will of course initially use its cost of capital and the regulators will use their concept of the social cost of capital. As far as our model goes, we suggest that this rate be keyed to Treasury bonds, which have a rate close to that of utility company bonds anyway, or that agreement be reached through negotiations.

**Source: Thomas Suchanek, Stony Brook University

5) The low efficiency of anti-pollution dollars at Brayton points to the social welfare utility of other standards or other approaches to maintaining equivalent standards. What is the cost of the alternate strategy of a cooling tower, which would relieve both the thermal and entrainment problems? What are the present value costs and benefits of an alternative of setting up a barrier in the Bay or building a cooling pond on the land the company already owns (with channels leading to the sea) to contain and control heated effluent and inhibit entrainment? The control of the heated water could be used for aquaculture (e.g., raising of oysters) and perhaps even to extend the bathing season.

6) Any quantitative or qualitative analysis of benefits and costs derived from alternative power plant designs must be made within the context of the environment of Mount Hope Bay. If the bathing water is severely polluted from sources other than the power plant, then cleaning up the power plant effluent is of marginal (if any) value. Environmental regulators should view pollution problems and standards in terms of community modules of environmental packages.

CONCLUDING COMMENT

This paper represents an effort to apply marginal techniques and a limited knowledge of technology to establish a framework of approach to a complex (though we maintain not impossible) set of problems which our society faces today and will face everyday in the future, whether or not people choose to keep their eyes open or closed. In the end, though, the ability of our society to solve its energy or any other problems will depend on the ability of people to work together and for the different interests to have good management teams. The system can only be as good as the people who run it are.

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LIST OF INTERVIEWEES

Environmental Agencies

Massachusetts Department of Mineral Resources, Mr. Robert Blumberg, Director.

Massachusetts Division of Marine Fisheries, Mr. Leigh Bridges, Assistant Director of Research.

Massachusetts Division of Water Pollution Control, Mr. Jack Elwood, Chief Sanitary Engineer.

United States Environmental Protection Agency, Mr. Conley, Chief of Refuse Permits.

United States Bureau of Sport Fisheries and Wildlife, Division of River Basins, Mr. David Crestin.

United States Bureau of Sport Fisheries and Wildlife, Division of River Basins, Mr. Ralph Schmidt, Chief of Permits and Licenses Branch.

United States Bureau of Sport Fisheries and Wildlife, Division of River Basins, Mr. Daniel W. Slater, Chief of River Basins Studies.

United States Bureau of Sport Fisheries and Wildlife, Dr. A. J. Nicholson, Assistant Chief of Operations.

Utilities

New England Electric, Mr. Ogden Sawyer, Chief Engineer and Vice-President.

New England Electric, Mr. John Hayward, Chief Mechanical Engineer.

New England Electric, Mr. Don Rose, Assistant Treasurer.

New England Electric, Mr. Robert Bigelow, Assistant Chief Engineer.

New England Electric, Mr. John Leborveau, Environmental Manager.

Long Island Lighting Company was briefly contacted.

Interveners

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SOME EXPERIMENTS RELATING TO THE

WOODS HOLE OUTFALL

Jean Nichols, Richard Chertow, and Robert Dwyer

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by

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Section 1. Introduction

One of the more interesting controversies currently prevailing with respect to the Massachusetts coastal zone involves the research community of Woods Hole, located in the town of Falmouth. Almost all the Cape disposes of its sewage by means of septic tanks. Woods Hole is an exception, currently discharging raw sewage to sea via an outfall located 200 yards offshore in Great Harbor. Falmouth is currently under state order to desist dumping raw sewage and the question the town faces is whether or not to build a sewage treatment plant and dispose of the treatment plant's effluent at sea and, if so, where, or to pump the sewage inland to a percolation system located in the Otis Air Force Base region. A third alternative which is currently not under consideration and not legally available to the town is to take the raw sewage further offshore and dump it there, perhaps in the middle of Vinyard Sound. It is not obvious to us what the ecological reasons are for arbitrarily barring this strategy from consideration.

There has been considerable study of the flushing characteristics of the various possible marine disposal sites (1) and some study of the problems associated with inland disposal (2). Therefore, we decided that the area we would concentrate on was the impact of the present outfall on primary productivity, nutrient levels, biomass, and species diversity in the area immediately surrounding (within six meters) of the outfall.

A control site in western Great Harbor of similar characteristics was chosen and all experiments duplicated at both locations. Figure 1 indicates the two areas. Section 2 outlines the results of those experiments. Section 3 discusses the implications of those results with respect to the decision currently facing Falmouth.

Section 2. The Experiments

Jean Nichols

Methods

The village of Woods Hole has a raw sewage outfall located 182 meters offshore from the Woods Hole Oceanographic Institution's dock (figure 1). For the past twenty years the village has been discharging mascerated and chlorinated raw sewage into an area that is subject to strong tidal action and short water-residence time. The mouth of the outfall pipe is located in 14 meters of water and discharges approximately 150×10^4 liters per day in summer and 85×10^4 liters per day in winter. Sediment around the outfall is predominantly a fine, black silt with an average carbon content of 13.7% within about 2 meters of the pipe mouth. This gradually decreases to about 3% at the extremities of the black sediment some 30 meters on- and offshore of the pipe (3). The bottom is characterized by numerous human artifacts such as aluminum foil, fecal material, cigarette filters and toilet paper. However, the level of the bottom is not raised in the immediate vicinity of the outfall.

The sampling program has been concerned with both benthic and planktonic observations. Diver-operated Birge-Ekman grabs were used to obtain samples for benthic community structure and diversity analysis. The samples were sieved through a 0.42 mm screen and preserved in 10% formalin. Animals were sorted and counted with a dissecting microscope. Water and sediment samples were also collected by SCUBA divers for nutrient and heavy metal analysis. Summer samples were obtained during July 1971, fall samples during October 1971, and winter samples during February 1972. The carbon-14 technique of Strickland and Parsons (4) has been used to determine primary productivity both at the surface and 10 m in depth. The samples were incubated *in situ* for six hours.

Preliminary results

During the seven-month sampling period at a control site in Great Harbor and at the outfall, benthic animals representing fifteen different classes were found in the Birge-Ekman grab samples. Two of these taxa were found only at the control site (Tables 1-3). A marked change in species composition was observed between the summer and fall samples. During the summer, nematode worms and the polychaete worm *Capitella capitata*, both indicators of stress conditions, were dominant at both the outfall and control site in Great Harbor. By fall the bivalve *Macoma tenta* and the polychaetes *Mediomastus ambiseta* and *Exogone dispar* dominated the control site while *C. capitata* and nematodes were still numerically dominate at the outfall. Animals with low stress tolerance (amphipods and cumacea) appeared in both outfall and control samples; however, diversity at the outfall had not changed significantly while doubling at the control site (Table 5). Both numbers and biomass were higher at the control site than at the outfall. By winter the control and outfall sites were again similar in species composition, numbers, biomass and diversity (Table 3). The bivalve *Macoma tenta* and the polychaetes *Spiophanes bombyx* and *Nereis sp.* were the numerically dominant animals at the outfall, while *Macoma tenta* and *Mediomastus ambiseta* were dominant at the control site. At this time phytoplankton productivity was similar in deep and surface waters at both sites.

There was no difference in the amount of available nutrients at the outfall or control sites at any one sampling time. Phosphate, nitrite and nitrate concentrations did not vary significantly between the fall and winter samples. Ammonia concentrations were one and a half times as large in February as in October (Table 4). This could be attributed to the bacterial breakdown of dead plant material.

Discussion

Winter nutrient measurements indicate that phytoplankton were not receiving nutrient enrichment, except directly in the plume. Dr. Edward Carpenter, however, found primary productivity to be approximately doubled during the spring bloom of 1971, but he did not measure nutrients at that time. No such response was found in January, 1972. We intend to measure both primary productivity and nutrients this spring to see if enrichment does occur.

A seasonal change in benthic community structure has occurred at both the outfall site and the control area in Great Harbor during the past seven months. The major control of community structure is the physiological tolerances of the component organisms, while animal abundance is related to available food and space (5).

With the onset of winter the most striking change in physical properties occured in water temperature. Dropping from 20°C to 4°C the water carried an increasing amount of oxygen in solution. It appears that the animal population structure has a natural change occurring in response to the observed seasonal changes in the environment. What portion of the change at the outfall is due to reduced effluent discharge is not known. However, since there is a lag in the winter increase in diversity at the outfall as compared to teh control site, it appears that the natural seasonal change is retarded, but not suppressed, by the organic load found around the outfall.

Section 3. Discussion of Implications

Richard Chertow, Robert Dwyer

The raw sewage outfall currently situated in Great Harbor at Woods Hole introduces a wide variety of pollutants into the marine environment of the areas. A brief outline of the levels of these pollutants and their effects follows. Data were gathered in 1971-1972, and can be considered representative of average seasonal outputs.

a) Nutrients.--Levels of nutrients introduced into Great Harbor apparently have no harmful effect on the biota of the harbor during fall and winter. Preliminary data for the spring phytoplankton bloom in 1971 indicated that primary production was approximately doubled. No data are available for the summer. Since nutrient concentrations are limiting to the phytoplankton during the summer, any increase in these concentrations can be expected to manifest itself as an increase in primary production above the level expected in non-enriched coastal waters (150×10^{11} liters/day in summer vs. 85×10^{11} liters for the rest of the year). Since the human population of Woods Hole, and thus the volume of discharge of the outfall, increases drastically during the summer months, nutrient enrichment may be expected to be greater than during the other seasons. Consequently, primary production may be expected to more than double during the summer.

If this much enrichment were to take place in a stagnant body of water, a serious eutrophication problem could occur. However, Great Harbor is very well flushed by tidal currents, and most of the enrichment is expected to be washed into Vinyard Sound and Buzzards Bay and diluted greatly. Thus, long-term effects of nutrient enrichment are not significant.

b) Bacteria.--A review by Orlob (6) of the residence times of different species of enteric bacteria commonly found in sewage reveals the paucity of knowledge on this subject. Many of the articles to which Orlob refers are laboratory studies of single species cultures, which almost never show any relation to the mixed species communities found in natural seawater. It is almost impossible to duplicate the conditions in the open sea in a closed laboratory system. However, the laboratory studies have revealed that the factors responsible for the death of sewage bacteria are organisms representing several taxa (6,7). Ralph Mitchell and others suspect marine amoebae and ciliated protozoa as the antibacterial agents. Some of the experiments suggest rather rapid death rates, others indicate that coliform bacteria may remain viable for as long as several days in sea water. The question remains unresolved, as well as the question of the health hazards posed by coliform bacteria. We were able to unearth no data on the longevity in seawater of bacteria which are established health hazards such as salmonella.

c) Viruses.--Quantitative studies on the viability of viruses in seawater have not been carried out. It is known that they are not affected much by primary or secondary sewage treatment, or even chlorination (8). Ozonation has better prospects for destroying virus particles, but this requires further study. It cannot be assumed, with the present state of knowledge on the subject, that viruses will be destroyed after secondary treatment, chlorination, and disposal in seawater.

d) Suspended and settled solids.--Large amounts of human artifact material (aluminum foil, toothpicks, toilet paper, etc.) were found in the immediate area of the outfall. These deposits disappeared beyond a radius of several meters. Suspended solids may be a problem on the same scale, affecting benthic fauna. On a larger scale, tidal flushing can be expected to clear most of the suspended solids from Great Harbor before sedimentation can occur.

e) Heavy metals.--Preliminary data indicate that abnormal concentrations of heavy metals may be present in the outfall discharge (see data in Section 2). Since the effects and recycling pathways of many heavy metals are not understood in any detail, little can be said quantitatively of their impact on the marine environment.

f) Fats and oils.--Little data are available on the hydrocarbon content of the effluent at Woods Hole. However, it is known that hydrocarbons raise the BOD of sewage more than most other forms of organic matter. Hydrocarbons, which are good nonpolar solvents, also tend to concentrate substances such as aromatic pesticides, increasing their potential deleterious effects.

Under order from the Commonwealth of Massachusetts, the Town of Falmouth must find a means of disposing of its sewage other than disposing of it, untreated, in the sea. Two plans have been proposed. One would have the sewage undergo secondary treatment and then be piped into 90' of water in Vinyard Sound (1). The other calls for secondary treatment of sewage and spraying the treated water over vegetation on land (2). A comparison of the two systems with regard to the aforementioned parameters is now in order.

Assuming spray irrigation is done correctly, nutrients present after secondary treatment would be taken up by terrestrial vegetation. Likewise, nutrients mixed with seawater would be utilized by phytoplankton to the extent dictated by the light and temperature at the particular time of year in question.

Bacteria and viruses should be eliminated by land irrigation. Their fate in sea disposal cannot be predicted with present knowledge.

Suspended and settled solids should be removed from the wastewater during secondary treatment, although this leaves the problem of the disposal of the sludge. Considering the possibility that the sludge may contain high concentrations of heavy metals, neither plan has an adequate plan for the safe disposal of the sludge.

Fats and oils should be digested during secondary treatment. BOD should be decreased adequately by both disposal methods.

One advantage claimed for the land disposal system is htat, in the process of irrigation, it replenishes the ground water supply. This is an obvious advantage, but it should be clear that the volume of water that is recycled is only a fraction of the projected water requirements of Cape Cod in the next few decades, considering the present rate of land development and population increase, and is probably not significant in the long run.

One problem with the irrigation system is that the fate of heavy metals cannot be predicted. The land disposal proposal (2) states that the soil should trap all heavy metals. We maintain that not enough is known to state this with certainty. Can the metals leach through into the ground water?

Questions of this nature concerning heavy metals and other toxic compounds must be answered adequately before a decision is made. Also, the proposal (2) does not adequately explain what is done with the waste water during the winter when irrigation is impossible.

The costs of the two systems are approximately equal, although a truncated version of the ocean disposal system, accommodating only the village of Woods Hole (not Falmouth Center) could be built for a fraction of the $8,000,000 projected costs. A defect in this smaller system is that it does not take into account the projected growth of Cape Cod. Expansion of the system is almost inevitable.

Summary

The observable effects of the present outflow appear to be limited to a radius of less than 10 meters about the outfall. Within this radius, there are rather marked changes in the summer and fall community, both with respect to dominant species, diversity and biomass. In the winter, there was almost no significant difference.

At present, no gross ecological damage appears to be occurring. However, the difference in summer and winter results, which is undoubtedly at least in part related to the heavier summer load, suggests that these results must be applied to larger systems with a great deal of caution.

TABLE 1 summerwater temp. 20° C

TAXA	Outfall n = 12		Control n = 2	
	no. / m^2	biomass/M^2	no. / m^2	biomass/M^2
Coelenterata	111	0·21 g		
Rhynchocoela	53	0·05	22	
Nematoda	4311	0·34	5185	1·272 g
Ectoprocta	89	0·64		
Oligochaeta	483	0·08	134	0·445
Polychaeta	2868	4·47	355	2·7
Pelecypoda	177	9·07		
Amphipoda	678	0·66	22	0·04
TOTAL	8814	15·53	5420	4·0565

TABLE 2 Fall water temp. 16°C

TAXA	Outfall n=6 no./m²	Outfall n=6 biomass/M²	Control n=1 no./m²	Control n=1 biomass/m²
Nematoda	23666	0·6178 g	7387	0·0445 g
Polychaeta	2203	2·5082	104891	42·0303
Oligochaeta	2121	0·5600	1113	0·0846
Ostracoda	185	0·0104	3160	0·8188
Amphipoda	230	0·5222	757	2·9682
Pelecypoda	497	1·9128	2850	27·6345
Gastropoda	230	0·4925	1113	0·5963
Sipuniculid	30	0·0030	890	0·2359
Anemone	44	0·4242	45	0·1469
Cumacea	59	0·0638	45	~
Decapoda	52	0·0645	223	4·0985
Rhynchocoela			3338	0·3338
Pycnogonida			45	0·0312
Isopoda			45	0·2670
Tanaidacea			89	0·0089
TOTAL	29317	7·1794	125991	79·2593

TABLE 3 Winter water temp. 4°C

TAXA	Outfall n = 2		Control n=1	
	no. / m^2	biomass/M^2	no. / m^2	biomass/M
Nematoda	30038	0·6863	13172	0·1113
Polychaeta	1068	16·3125	9523	12·0195
Oligochaeta	2003	0·3257	5696	0·9790
Ostracod	45	0·0180		
Amphipoda	223	1·5537	178	0·2804
Pelecypoda	801	21·2670	3827	44,5
Gastropoda	178	0·3302	178	0·3026
Cumacea	89	0·1157		
Rhynchocoela	668	0·0447	979	0·0490
Decapoda	89	0·2270		
Isopoda	45	~		
TOTAL	34247	40·8808	32574	58·2418

TABLE 4

Nutrients (ug a / L)

		PO_4	NH_3	NO_2	NO_3
FALL	Outfall	1.47	0.643	0.088	0.009
		1.10	0.517	0.118	0.035
		0.96	0.624	0.090	0.00
		1.49	0.686	0.058	0.071
		1.06	0.574	0.126	0.00
	Control	0.87	1.20	0.038	0.158
		0.90	0.62	0.048	0.124
		0.91	0.76	0.038	0.155
		0.96	1.13	0.030	0.386
		0.88	1.76	0.034	0.621
WINTER	Outfall	1.08	2.46	0.110	1.31
		0.79	2.00	0.110	0.37
		0.91	2.56	0.110	0.22
	Effluent	22.05	125.0	2.36	567
	Control	0.92	2.81	0.14	0.25
		0.81	3.12	0.083	0.23
		0.80	1.92	0.086	0.21

TABLE 5

Primary Productivity 1/18/72
($mg\ C/m^3/hr$)

	Depth	
	surface	10 meters
Outfall	0.15 0.11	0.13 0.24
Control	0.24	0.12 0.23

Chlorophyll a (ug/l)

Outfall	3.19
Control	2.58 2.58

Diversity (H)

	summer	fall	winter
Outfall	1.037 2.144	0.7963 0.6931 1.4811 0.0000 1.9992	2.248 2.005
Control	1.154	2.2477	1.772

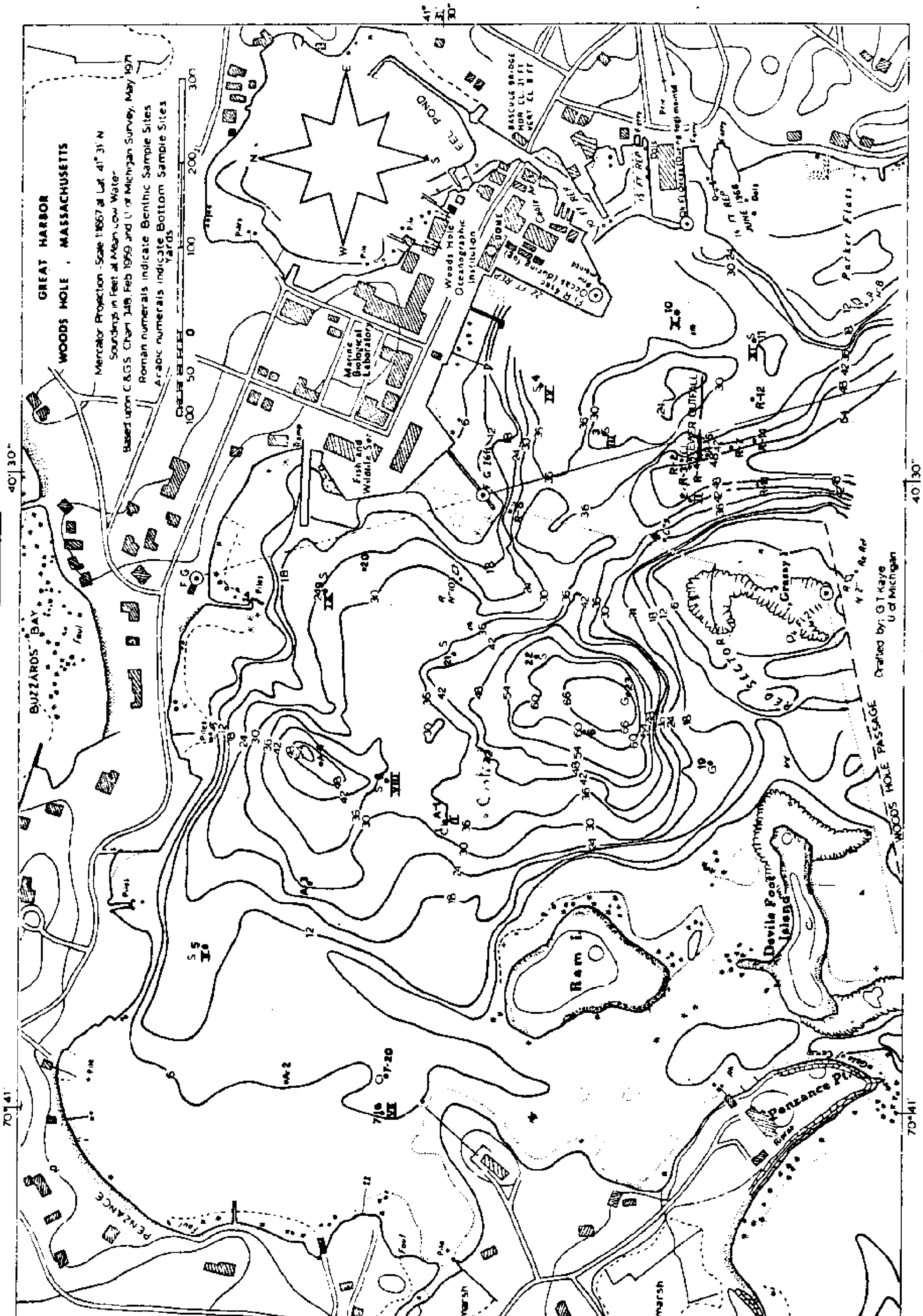
GREAT HARBOR
WOODS HOLE , MASSACHUSETTS
Soundings in Feet at Mean Low Water
Roman numerals indicate Benthic Sample Sites
Arabic numerals indicate Bottom Sample Sites
Yards
BUZZARDS BAY
EEL POND
Marine Biological Laboratory
Woods Hole Oceanographic Institution
Parker Flats
Grassy I
Ram I
Devils Foot Island
Penzance Pt
PENZANCE
WOODS HOLE PASSAGE
marsh
Drafted by: G T Kaye
U of Michigan

Figure 1

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