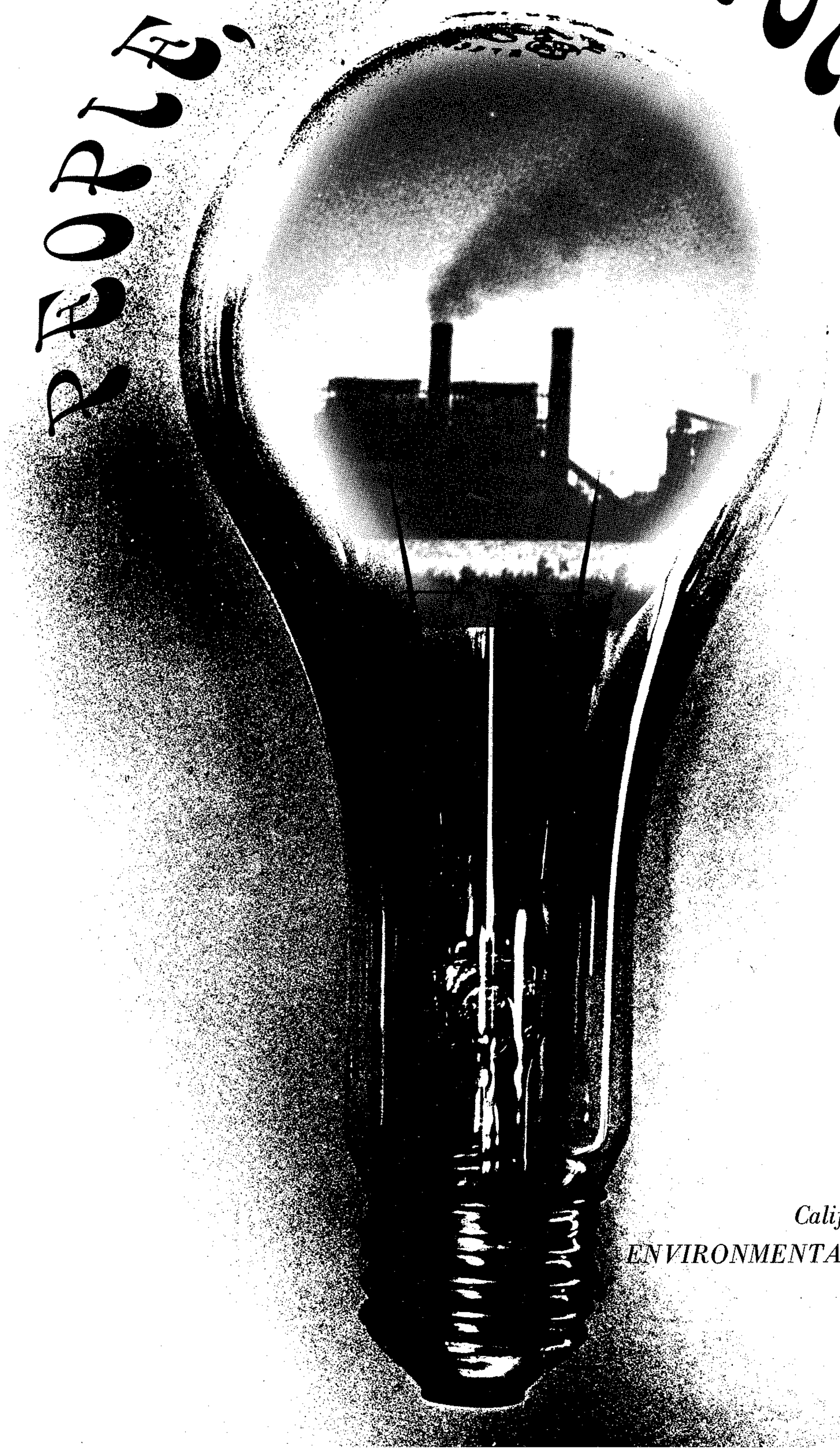
Report No. 1

PEOPLE, POWER, POLLUTION



California Institute of Technology
ENVIRONMENTAL QUALITY LABORATORY

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PEOPLE, POWER AND POLLUTION:

ENVIRONMENTAL AND PUBLIC INTEREST ASPECTS OF ELECTRIC POWER PLANT SITING

by

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Explanatory Note

On March 16, 1971, the National Academy of Engineering convened the Forum of the Committee on Power Plant Siting (COPPS) in Washington, D.C. After two days of plenary sessions the members of the three main working groups met for three days to begin drafting their reports. Four of the authors of the present report (Borrelli, Easterling, Lees and Poppe) constituted the sub-group on Environmental Aspects of Siting of Working Group II–Systems Approach to Site Selection. Intensive discussions in Washington in this sub-group, and the subsequent exchange of draft sections by mail, convinced us that we should go far beyond our original assignment and probe into all aspects of power plant siting, especially the public interest factors. During a second intensive working session in Pasadena, California, on April 22 and 23, 1971, we were joined by Guy Pauker and Burton H. Klein, who also participated in the subsequent redrafting of the final report.

We are grateful to the NAE-COPPS for stimulating our thinking on this important and difficult problem. However, the final report is solely our responsibility as individuals and the responsibility of the Caltech Environmental Quality Laboratory.

Lester Lees
Director, Environmental Quality Laboratory

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CONCLUSIONS:

1. We are beginning to deal with the environmental damage caused by our rapidly increasing demand for electricity. But the environmental problems we have now are small compared to those we will face in the future if we continue to generate electricity at the present rate of increase. It has been suggested that the growth rate of electric power consumption must be curtailed. There is some indication that the rate of increase will, in fact, slacken. Yet, even assuming near zero population growth, a drop to one half the present rate of growth in individual wealth, and a corresponding 50 percent reduction in the current rate of increase in power use in the next decade, U.S. consumption of electricity will *still* triple by 1990.

At a time when there is scarcely a place in the country where a power plant can be built and operated without public opposition, we must plan sites for three times more electric generating capacity than we now have.

2. Social values of Americans are changing. The growing consumption of electric power comes into direct conflict with the insistent and increasing public demand for a better environment and more careful attention to other public interests in private decisions.

Systems engineers who design power plants and select sites for them can no longer consider only traditional technical and economic factors. They must give equal weight to public interest factors from the very beginning of the engineering process. The *cost* of failing to do so will be lengthy delays in legal actions and very probably more frequent power shortages in the near future. Yet the traditional engineering goals of supplying enough electricity at the cheapest possible price cannot be abandoned: environmental factors will increase the cost of power but the increase must be kept to a minimum.

3. How do power plant planners take public interest factors into account? How are these factors identified? The answer is that planning must be opened to the public; the public must be involved in new forums of participative decision-making. And utilities must come to these forums recognizing their validity and freely surrendering the prerogative of unilateral decision-making. This, however, leaves the central question of who "the public" is, and who effectively speaks for the public. As to this, there is no general theory. The answer varies from place to place and conflict to conflict. However, recent successful attempts to involve the public seem to have the following characteristics:

a. Citizen groups are brought in before, not after, the major decisions have been made.

b. Utilities are completely open to public discussion and accept the input of any interested party, no matter how "extreme."

c. Utilities fully disclose all information felt by public spokesmen to be relevant to the issues.

d. All sides actively seek means to resolve the conflict.

e. All sides regard adversary proceedings—court actions—as the last resort—to be used only when all other methods of conflict-resolution have failed.

4. A system of governmental air and water quality regulation is developing in the nation based on three distinct kinds of goals: (1) *ambient* air and water quality standards, which are long-term national goals established considering only the levels of pollutants which must not be exceeded to assure the health and welfare of the people; (2) *management* air and water quality standards, which are a series of steps toward the long-term goals that are determined by technical and economic feasibility at a particular time in a geographic region; (3) *emission* standards, which are used for regulation of pollution sources in order to implement the goals set out in the management standards and, ultimately, the ambient standards.

This is a practical system, but it will work only if management standards are accepted by both utilities and the public as concrete milestones on the way to an acceptable environment; and ambient standards are understood to be long-term, but realistic, goals.

5. While institutions have been developing for the resolution of conflicts between public and private interests in the use of air and water, the same has not been happening for land and natural resources. Much of the opposition to specific power plants has concerned land use rather than pollution. There is no overall system for considering the best use of land in the broadest environmental and economic contexts. The situation is similar–if not worse–for the allocation of natural resources, particularly energy resources. In some cases, the use of a particular clean fuel might make the difference between an acceptable and unacceptable power plant. Yet no method presently exists for allocating fuels to various users in an environmentally efficient way.

6. The electric power industry will invest $250 billion in power generating equipment during the next two decades. Traditionally, the industry has relied on its suppliers for development of better ways to generate and distribute electricity. The result has been an underdeveloped technology for meeting the demands imposed on the industry by the new requirements for increased power with minimum environmental damage. Areas in which research is needed are: (1) development of new energy sources, such as solar energy conversion; (b) control of emissions from fossil-fuel burning plants; (c) development of beneficial uses of waste heat, such as mariculture; (d) reduction or elimination of radiation hazards; (e) development of novel methods of power plant siting, such as off-shore and underground.

A new mechanism–perhaps a federal agency or a private organization financed by the power industry–must be created to carry out a major industry-wide research and development program. Whether the mechanism is public or private, the costs should be assessed against the users of electricity, in proportion to their consumption.

RECOMMENDATIONS:

1. OPEN PLANNING INSTEAD OF PRIVATE PLANNING: The public interest in the environment is as important as the traditional economic and technical considerations that usually determine the design and location of power plants. Utilities should, therefore, admit *all* spokesmen for the public interest, no matter how "extreme," to the power plant planning process from the very beginning. The courts should be the last resort, not the first opportunity for the public to be heard.

2. PUBLIC INTEREST IN THE LAND AND NATURAL RESOURCES: Effective methods for mediating conflict over the use of air and water are evolving–but there are no institutions for articulating the public interest in private decisions about the use of land and natural resources. Such institutions must be created, and the need is especially great in the case of power plant siting.

3. A MASSIVE ENERGY EFFORT: Present research and development of the power industry is totally inadequate, considering both the amount of energy this country uses and the urgency of the need for cleaner and more efficient technology. So much electricity is being used in the United States today that a tax or charge of only one-half a mill (one-twentieth of a cent) per kilowatt hour could raise three quarters of a billion dollars a year for an accelerated program of government or industry-sponsored research. Such a program should be undertaken without delay.

1

Introduction: SOCIETAL DEMANDS, CONSTRAINTS AND CHOICES

1. *Introduction: Societal Demands, Constraints and Choices*

1.1 Growth in Electrical Energy Demand

Forecasts of future electric power demand usually amount to linear extrapolations of past history on a semi-log plot—the "exponential growth syndrome" of modern industrial society. Can we identify sociological values that could lead to a gradual reduction of the rate of growth in the demand for electrical energy over the next ten to twenty years? This question is under intensive study by many groups; here we list only a few major factors that might lead to a 'slowdown" in the rate of growth of electric power consumption per capita:

(a) Shift from single-family homes to multiple dwellings in new residential construction. (A single family apartment uses about 2/3 of the electric power consumption of a single family home).

(b) Increase in mobile homes as a percentage of new residences, especially in the price range below $18,000.

(c) Slowdown in the rate of growth of the labor force over the next 20 years.

(d) Reduction in number of hours in the work week.

(e) Shift in labor force from manufacturing to less power-intensive service and trade occupations.

(f) Increase in electric power rates (in 1971 dollars) caused by increasing fuel costs, and by new methods of power plant siting and waste heat management dictated by environmental constraints.

Of course, growth-stimulating factors can also be identified; some examples are as follows:

(i) increase in productivity per worker in manufacturing, leading to a growth in real income per capita, and a growth in demand for everything, including electric power

(ii) climate control (winter and summer) for houses, patios and public places

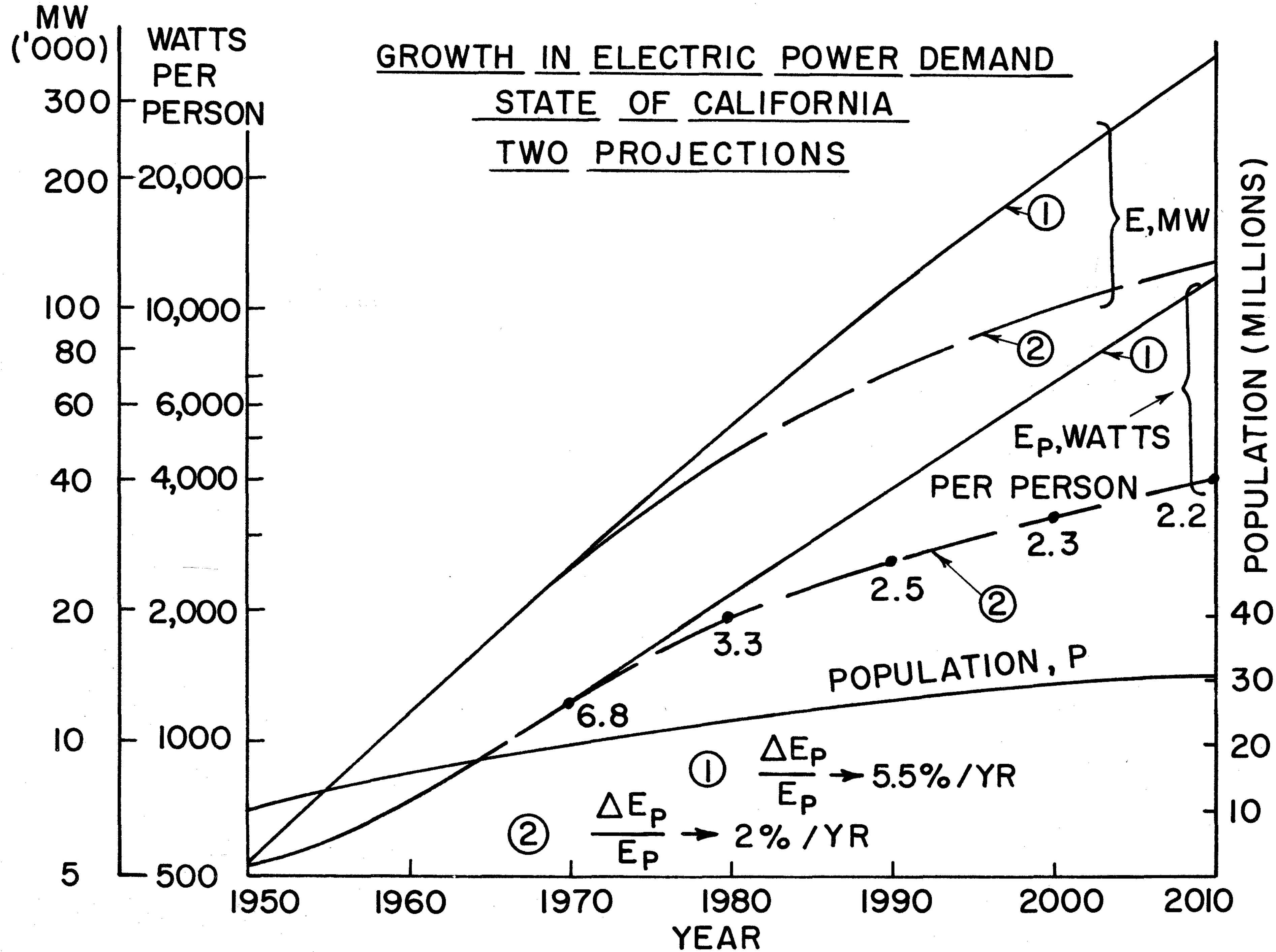
(iii) urban public transportation (electric) and electric automobiles

Suppose that the factors pushing in the direction of a slowdown in the rate of increase of electric power demand should win out; what would the impact be? In order to throw some light on this question we have chosen a highly simplified "minimum growth" model with a single "time constant," in which the equivalent exponential growth rate in per capita demand drops from its present value of 6.8%/year to one-half of this value in about 10 years, and gradually approaches a constant value of 2%/year. The results are shown by the curves labelled 2 in the attached Figure (taking the State of California as an example).

In 1970 the per capita demand for electric power (E_p) in California was 1260 watts/person; according to the projection represented by curve 2, E_p will increase to 2600 watts/person by 1990, and to 4120 watts/person by the year 2010, or about 3.3 times present per capita demand. (The numerals along this curve denote the "local" equivalent exponential growth rate). By comparison a projected "Maximum" growth rate in E_p of 6%/year in the period 1970-1990, and 5.5%/year in the period 1990-2010, leads to values of E_p of 4150 watts/person by 1990 and to 12,500 watts/person by the year 2010 [curve 1]. During this same period the projected growth in population plays a secondary role compared to the differences in these two projections of E_p. The population growth rate was about 1.5%/year in 1970, and the rate is projected to drop to about one-half of the value by 1990, and to zero by the year 2010 (see Figure).

One of the most striking conclusions to be drawn from the Figure is that the projected electric power demand (E) ten years hence given by curve 2 is only slightly lower than the demand shown by curve 1, even though the rate of growth in E_p falls to one-half of its present value by that time. As Dr. Burton Klein of Caltech has pointed out, if we wanted to influence demand in 1980 we should have started controlling the rate of increase in E_p in 1960. By the same argument, if the curve of E_p vs. time does not start "bending over" until 1980, electric power demand in 1990 will be just about as large as predicted by curve 1, and a significant effect on demand would not appear until the year 2000.

Even the "minimum growth rate" projection illustrated by curve 2 calls for an almost *threefold increase* in electric power demand in the State of California by the year 1990. Because of their cumulative effect, small unpredictable increases in growth rate above those shown along curve 2 for E_p would lead to an even larger power demand 20 years hence. By comparison the "maximum growth" projection [curve 1] shows a 4.6-fold increase in electric power demand by 1990. Allowing for increased imports of electric power from outside the state, and for the planned enlargement of generating capacity at existing sites, 14 new plants of 4000 MW(e) each would by required by 1990, according to curve 1 . These considerations show that we need to develop a long-range (40-year) electric power plant siting plan that is flexible enough to cope with uncertainties, without provoking a new environmental "crisis" every 7 or 8 years.


GROWTH IN ELECTRIC POWER DEMAND
STATE OF CALIFORNIA
TWO PROJECTIONS
MW ('000)
WATTS PER PERSON
300
200
100
80
60
40
20
10
5
20,000
10,000
6,000
4,000
2,000
1000
500
E, MW
E_P, WATTS PER PERSON
POPULATION, P
POPULATION (MILLIONS)
40
30
20
10
6.8
3.3
2.5
2.3
2.2
① $\frac{\Delta E_P}{E_P} \rightarrow$ 5.5% / YR
② $\frac{\Delta E_P}{E_P} \rightarrow$ 2% / YR
1950
1960
1970
1980
1990
2000
2010
YEAR

1.2 The Systems Engineer and Societal Constraints and Choices

The growing demand for electric power (Section 1.1) comes into direct conflict with the insistent and growing public demand for substantial improvement in environmental quality and careful attention to other public interests. In order to resolve this conflict the basic premise of good systems engineering as applied to power plant design and siting will have to change in a fundamental way. Minimizing adverse effects on the environment and providing for the energy needs of society must now be regarded as co-equal objectives right from the beginning. Public acceptability and related political considerations are no longer "external" factors. Although the engineer may sometimes regard such considerations as "irrational", they are often powerful and even decisive, and they need to be included in any generalized systems analysis that is supposed to deal with the total problem.

The systems engineer today is confronted by a set of societal "vector forces" pushing in different directions, and he has the challenging and difficult task of working out a balanced solution (Section 2). Public and private utilities have usually insisted that no constraints should be placed on their operations unless it can be clearly demonstrated that these operations produce a definite, measurable adverse effect on the environment. On the other hand, most environmentalists insist that an action should not be permitted if there is even a small chance that it will produce harmful, irreversible effects on the environment. These two opposing points of view often present a severe problem to the engineer, who may not have sufficient "hard information" to know the effect of a prospective action and who may not have time to wait for the results of a long-range research program. In the resolution of such a dilemma "dynamic factors" can be decisive; for example, the predictable steady reduction with time in the permissible levels of sulfur dioxide and particulate emissions, or in the allowable temperature excess above ambient of thermal discharges into natural bodies of water. (See Appendix A) When all factors are considered, it may be more helpful to society (and even less costly) to select a closed-cycle cooling system than to wage a long legal battle against restrictions on thermal discharges.

In arriving at a balanced solution the systems engineer may find it imperative to involve working groups of volunteer environmentalists and other public interest groups in the planning operation from the outset. The obvious risks of such "open planning" (Section 2) are often outweighed by the fresh thinking of concerned citizens and by the benefits of exposing an important, activist segment of society to the hard choices that we all face. Of course if this process is to be meaningful the systems engineer needs to keep open a wide range of possible choices of fuels, plant sites and waste heat management schemes, and not foreclose certain alternatives *in advance* because of relatively narrow (within 10%) cost considerations.

The objective is to do the best possible job of minimizing the adverse environmental impact of power generation and transmission, and let the public decide when the additional costs of additional reductions in environmental impact are too large. The rate-setting mechanism provides a built-in method of "internalizing" the costs. It could also be designed to provide incentives to develop beneficial uses of waste heat, such as biochemical treatment of sewage, mariculture, etc., and incentives for multiple uses of the land around power plants and under transmission lines. At any rate the process of determining what the public will pay for electrical energy under environmental constraints is necessarily iterative and experimental at present. Perhaps experience and a better understanding of complex environmental interactions will permit some relaxation of "standards" in the future, but in the meantime the "better-safe-than-sorry" approach has much to recommend it, especially when we recall the history of "smog", eutrophication, mercury poisoning and other environmental disasters. This position of the environmentalists is now being enforced by legal and political actions.

1.3 Decision Making During a Period of Paradigm Change

There are three kinds of decision-making processes that are of interest here. The first is aimed at static efficiency; the combination of more or less known inputs in a way to minimize costs and to maximize profits. This kind of decision-making, and the highly static systems engineering approach which goes with it, has been characteristic of the electric power industry in the past. In the second kind of decision-making process the aim is a high degree of dynamic efficiency; the combination of new scientific and technological ideas to produce a new menu of technology. This kind of decision-making and the highly dynamic systems approach which goes with it is characteristic of the planning and organization of Bell Telephone Laboratories. The third kind of decision-making is decision-making in the face of paradigm changes, when new fundamental assumptions enter the picture. In science such revolutionary periods characterized the change from the Ptolemaic to the Copernican world-view in astronomy, or from the Newtonian to the Einsteinian universe in physics. The contemporary systems engineer must now adjust his thinking to a world in which private interest considerations, expressed by concern with economic and technological efficiency, will have to be reconciled increasingly with public interest considerations of environmental management. The systems engineer sensitive to such paradigm changes will attempt to resolve potentially dangerous social conflicts in a relatively peaceful and democratic way; and thereby to pave the way for a new regime of dynamic and later, static efficiency. This kind of decision-making was characteristic of the way many labor disputes were resolved at an earlier part of our history. And it is also characteristic of the way politicians like La Guardia went about dealing with social conflicts. The general aim in such conflict resolution is to substitute the doctrine of pragmatism for high "principles".

Though the proponents of each of these three kinds of decision-making processes believe that theirs is the "right" way, and right for all periods of history, all of them can be the right way of making decisions, or the wrong way of making decisions, depending on the period of history in question. For example, it certainly must be acknowledged that the long hard fight on the part of the electric power industry to keep costs down has had something to do with the high productivity of this country; just as it must be acknowledged that the sense of excitement and adventure which has characterized BTL's efforts had something to do with realizing its long-term goal, which from the beginning was to provide the U.S. with a cheap and reliable telecommunications system.

On the other hand, there are periods of history when neither of the first two decision-making processes will work. In general, they are the periods of history when it is necessary to change course to make a new kind of history. And it is such a period of history that we are in now—a period in which new kinds of paradigms must be evolved. The principal characteristic of such periods is the kinds of uncertainties involved. Not only are there scientific and technological uncertainties—uncertainties about *how to get the job done*—which are quite as great as those faced by BTL in say, 1920; but there is also a good deal of uncertainty as to what the job is. For example, some of the power companies believe that the job is to continue to produce power at the lowest possible cost, and to take environmental constraints into account only insofar as damage can be clearly demonstrated. On the other hand, the ecology movement contains some extremists who, in their great desire to preserve the natural environment, almost do not care what happens to man. He is admonished to renounce the values of modern society, and to adopt, forthwith, the values associated with medieval asceticism Moreover, as happens in all periods of crisis, there are those who see in them an opportunity to sell their "pet" schemes. In particular, coalitions of engineers are now forming to sell their technological dreams. Many of them accept the "Earth is a Spaceship" concept but want Noah's Ark to be outfitted in the most up-to-date technology. Their motto, in other words, is that if we must have "zero growth", let's have it in high technological style.

The general idea of open planning is to try to define the job in a way that will avoid any of these extremes. To do this, the various extremist groups (including the technological "fix" types) must engage in serious conflicts, for without such conflicts, paradigm change never can come about. On the other hand, the satisfactory resolution of such conflicts requires people who, unlike the authors of this paper, do not have an axe to grind. For example, when it comes to resolving such conflicts, the average woman probably has much more sense than any engineer, environmentalist, or economist.

In brief, then, *decision-making during periods of paradigm changes is very stormy business, the outcome of which no one can guarantee.* And the only thing which really can be said for open planning, which is really an attempt to revive the kind of town hall planning which worked so well in former periods of this country's history, is simply that there is no alternative in sight which is guaranteed to work better. No one likes stormy history, but unless a way is found to resolve serious conflicts, there is no way to get on with the business of making a new kind of history.

One can state only the general objective of such open planning. The objective is not simply to find a way to resolve conflicts—to form new alliances between two groups which would resolve their conflicts at the expense of a third group. It would be easy, for example, to contrive a scheme which satisfied the interests of conservationists for preserving the environment but which left other segments of society out of account altogether. It would be easy to forget, in other words, that the ecology crisis is not the only crisis facing this country. The aim therefore, must be to take into account a variety of interests in the best way possible—remembering, of course, that some degree of sacrifice will be required all around. On the other hand, the aim must be to help minimize the degree of sacrifices. For example, ways have to be found to assure that to the extent environmental factors are taken into account in power plant siting, they are taken into account in the least costly manner. And ways have to be found that permit standards to be worked out in a pragmatic way and which will take into account the difficulty of meeting them. Finally, ways have to be found to produce a good deal of rapid feedback, so all concerned can learn from each other's experience.

In Section 2 the practice of this new systems engineering, including "open planning", is examined in more detail. Section 3 deals with some illustrative case histories of conflict and resolution involving air quality, water quality and thermal discharge, and aesthetics and land use, and Section 4 examines briefly the economic aspects of environmental constraints on power plant siting. In Section 5 we treat the problem of regulation and standards. Section 6 discusses the unresolved national problem of organizing and stimulating the required development and research on reduction in emissions, novel methods of power plant siting, new energy sources, etc. Finally, in Section 7 we examine the long-term prospects for power plant siting and power generation in the post-1985 time period.

2

OPEN PLANNING AND SOCIAL FORCES

2. *Open Planning and Social Forces*

2.1 Introduction

The development of a systems engineering approach to environmental problem solving, and specifically the siting of future power generating facilities is not a new process pertaining to this area of concern. Systems engineering has been used by most utilities in the past in selecting and developing sites for power facilities and yet, this process has resulted in conflict and delays. New problem solving and decision-making mechanisms are needed which will enable utilities to site future facilities which are in keeping with the environmental, social and political needs of the public.

What can produce workable solutions? A broader perspective is the key, together with a forum which encourages, if not requires, that perspective. This perspective must be brought to new or restructured forums—eventually, these will be primarily governmental.

What will be the nature of these new forums? That will probably be determined more than anything else, by the failure by one level of government to deal effectively with the problems in a timely way which will cause them to go by default to another level. The temper of the times will not permit the problems to go unsolved.

These new governmental forums eventually must look to regional problem-solving which ignores the unrealities of political boundaries. However, a regional approach will be a long time coming. Local and state's rights is a concept too dearly held at the present time.

It is often suggested by electric industry representatives that what is really needed is more government, more regulation, i.e., just tell us what the rules are and we will obey them. While more regulation is probably what is going to happen, it is not a complete solution. There is, to be sure, a compelling need for some order and rules—both procedural and substantive—upon which industry can rely. However, a call by industry for governmental regulation—whether state or federal—must never be a substitute for individual corporate responsibility. The end result of this approach for corporations is only to place some of the real management opportunities in the hands of a political body. These remarks should not be taken as a polemic against government regulation. Corporations must always recognize that the letter of the law is but the beginning and not the end of corporate response.

2.2 Involving the Public

The really crying need is to give prime attention to establishment of new forums which allow room for participative decision-making. Utilities must come to these forums recognizing their validity, and freely surrendering the prerogative of *unilateral decision-making*.

There are several new ways for industry to think about environmental problems. To those industries such as utilities which are heavily involved in environmental matters, there is one keystone proposition which must be understood and accepted.

The basic problem lies with the fact that utilities make internal judgements based on their evaluations of economics and operational needs–although increasingly tempered in recent times by *their* interpretation of the public will. While that basic process is obviously valid and must continue, it has one fundamental weakness. The "public" (however one may choose to define it) does not have an opportunity to participate until after the decision is made and after the point of no return is passed. Many institutions are finding that this procedure is no longer acceptable, e.g., universities, the organized church, government.

The unacceptability of this "institutionalized decision-making" focuses most sharply on those areas where the public feels it is most intimately involved. Thus, students and faculty feel they ought to have a larger role in university policy formation. Utility rate payers feel they ought to be able to declare how *their* money should in part be spent for environmental protection. Citizens feel they have the right to judge the environmental impact caused by extraction of *their* mineral resources. The list of those major corporations for which the public if fast developing new definitions of corporate responsibility reads like an industrial "Who's Who".

In the future less and less will any institution be able to decide unilaterally what its particular public should have. More and more, the corporate task will be to determine what its particular public wants and then to do it. In the case of public utilities, that is another way of asking: What is the public willing to pay for? Utility obligation then will more and more involve a *complete* disclosure of *facts,* and less and less will it involve passing judgement on those facts.

The relationship between unilateral decision-making by utilities and patterns of public political resistance toward proposed nuclear power plants and the siting of these facilities has been studied by David G. Jopling and Stephen J. Gage of the University of Texas. The results of their study of the patterns of resistance towards the Enrico Fermi proposal, Lagoona Beach, Michigan; Pacific Gas and Electric proposal, Bodega Bay, California; Consolidated Edison proposal, Cayuga Lake, New York; and Northern States Power proposal, Monticello, Minnesota, clearly show that the resistance towards this additional generating capacity could have been reduced if not completely eliminated if these utilities had only involved those interested segments of the public in their pre-decision planning process.

Therefore, if a *new approach* to the siting and development of future generating facilities is to be designed which will prevent undue delays in their construction and operation, then open planning and participative decision-making must be an integral part of this problem-solving mechanism.

What is open planning, who should participate in this process, and where should it fit into the total systematic process of technological, ecological and sociological planning? These are difficult questions for which there is no single right answer, but a variety of possibilities. The open planning approach is dependent on the time available for this process, the geographic area, the public credibility of the utility in question, the nature and attitude of the critics involved, and the degree of openness and flexibility of alternatives available to the participants.

Simply defined, open planning is a process which *actively* seeks outside inputs, ideas, evaluations—and participative decision-making utilizes open planning as a means of determining the *needs* of the *public*. The important words in this definition are "actively" and "public"; and the success or failure of the process is dependent on the quantity and quality of active public participation.

The greatest difficulty an institution will encounter when entering the realm of open planning is the determination of who is the public with which it should work. When seeking an answer to this question the following suggestions may be helpful:

1) "Public" and "government" are, of course, not synonymous. One cannot rely only on the regulations and standards of federal, state, or local authorities as a

means for determining public needs.

2) The "general public" or a balanced cross section of the public is not the "public" of interest in this process either. The active, involved and concerned public are partisan groups and these groups will unavoidably involve critics, who would at first sight, seem to complicate the planning process.

3) Particular individuals should not be sought out, but rather representatives suggested by organizations.

4) Relying *solely* on consultants, no matter how concerned towards the environment they may be, should not be construed as open planning. This method will only increase problems of credibility for both the institutions and the consultants involved, because lacking the backing of partisan groups they can be more easily suspected of subservience to the power industry.

5) No matter how radical, unrealistic or unqualified certain spokesmen for different points of view may appear to be, they should be allowed to express their point of view and participate in the debate.

If a corporation decides to utilize an open planning forum it should work with the public in the pre-decision stage. Initiating this process after major decisions have been made immediately places the company in a *defensive posture,* and a generally unproductive (for all concerned) advocate/adversary environment will prevail.

Yale economist Charles E. Lindblom has pointed out repeatedly (e.g., in his "The Intelligence of Democracy—Decision Making Through Mutual Adjustment", 1965) that good decisions are those based on consensus. This does not mean that the power industry must accept the endless delays that might be involved in reconciling the interests and values of conflicting groups with diametrically opposed points of view. But the process of open planning does often expose the unreasonable position of extremists and rallies the majority in support of a sensible problem-solving solution (see Section 3.2).

Furthermore, the systems engineer and other systems analysts are not necessarily experts at determining by themselves what interests and values may impinge upon the system with which they are concerned. Other skills, those of the social sciences, are required to identify and weigh such values and interests operative at that particular time in that particular community. The results of such inquiries, assuming that they would be skillfully conducted, could nevertheless become the subject of considerable and possibly bitter controversy. Their credibility would be hard to establish and defend.

By contrast, open planning would amount to an invitation to all such interests and values to "stand up and be counted", to make themselves heard in a public forum, open to the scrutiny of all other partisan groups. The accusation that certain interests or values had been ignored or suppressed could no longer be voiced after the open planning process had taken place.

The systems engineer would gain from such a process the knowledge that would permit him to experiment with alternative solutions, based on a range of assumptions in which different values and interests could be ordered according to different hierarchies of priorities. Such alternative models could then become the basis of more sophisticated cost-benefit analyses, which might show that the cost of taking into account certain "external" (i.e., non-economic) factors would be a reasonable price to pay for wider community support.

The major obstacle to such an effort is distrust, and the corporation must work long, hard and patiently to overcome this obstacle (not only distrust by the environmental community, but also the distrust that exists within the corporation itself). The whole process must be based on an implicit faith in the rational man. Once this distrust is overcome (if this is possible), the problems assume an entirely new scope.

Open planning is at most an experiment and at best a transitional forum which will be replaced in the future by new open planning forums where citizens groups and corporations will work with government in a semi-formal gathering, but hopefully not in a hearing format. Hearings require predetermined positions and tend to stifle flexibility and cooperative planning. If open planning fails, the advocate-adversary approach of public/governmental hearings are necessary, but it should not be looked upon as the only means to an end—especially when the objective is public involvement in planning processes.

Corporate involvement in these processes demands considerable commitment to the philosophy of open planning. It will be necessary to experiment until a method is formulated which fits the needs of the period and the problem. These needs will change constantly and the process must be flexible enough to change with these needs. The risks are high, but the benefits will be the lack of delays and new insights pertaining to problem-solving alternatives.

2.3 Recommendations

Consultation with state and public groups should begin long before public resistance to the proposal is openly voiced. The utility company should pull the public into the planning and decision process for plants, including the design, siting and construction activities. The company should abandon any traditional public relations policy that emphasizes corporate anonymity and should establish a wide range of unobstructed and flexible communication channels with the general public.

A utility should make both formal and informal efforts to incorporate the public into the decision processes. Formally, the company should actively lobby for the creation of a broadly representative task force, either at a state or regional level, to advise the utility's long-range planning staff on the siting of all electric power facilities (fossil-fueled, nuclear-fueled, hydro, pumped storage, etc.). The company should also establish a permanent environmental affairs division with interdisciplinary capabilities for liaison with regulatory agencies and environmental groups.

If the creation of a formal advisory body is not possible, the company should continue to seek public participation by inviting relevant state agencies and environmental groups to inspect plant sites and to reconcile differences over what constitutes the best site alternatives. In a further effort to communicate with public groups over ecology problems, the company, in cooperation with appropriate government agencies, should hold numerous workshops and public hearings on the plant proposal but with ample notice being given to any public groups and individuals who have expressed an interest. The company should specifically invite potentially important groups that do not appear on their own initiative.

The format for public hearings should include a request for each state and public group to present what it regards as the important history and potential uses of each alternative siting locale. These hearings should present government, environmental and public representatives with a clear picture of what operating experience shows can be expected from the proposed plant. At no time during these hearings should the company or any of its representatives withhold relevant material of a technical, economic, or political nature, unless such material is *truly* proprietary in nature. The utility should be prepared to emphasize compromise very early if difficulties arise over siting alternatives. Once an accord has been reached with public groups, however, the utility company should call upon the state and public groups that contributed to the accord to support the siting agreement that has been reached.

In some cases it will be impossible to convince certain environmental groups or concerned individuals to participate openly in such public forums, yet their input is desirable. If such instances arise, private briefing sessions should be offered in order to seek their reaction to utility proposals. Every possible effort should be made to work with these people.

At times it will also become necessary to negotiate not only on the alternatives of new proposals, but on alterations to existing facilities. A willingness to "up-date" past decisions could easily make or break future open planning activities.

There are ways for the electric power utility to avoid escalating the environmental credibility gap. But clearly no easy solution will be forthcoming for this problem Foreseeable developments in reactor technology cannot completely mitigate the possible release of radioactive materials nor do they offer much hope for significantly reducing thermal effects. Significant developments in gaseous emissions control for fossil fueled plants are also not within easy reach. A constantly changing societal value system presents the utility with a moving target of public expectations. In conclusion, the electric power utility must recognize that only resolution, not solution, of power plant siting is possible; that political processes based on a continued working out of differences is the reality to be expected.

3

CASE STUDIES OF CONFLICT AND RESOLUTION

3. *Case Studies of Conflict and Resolution*

3.1 Introduction

As emphasized in Section 2, no general theory exists that would lead to a systematic procedure for the resolution of conflicts over power plant siting. Environmental and aesthetic factors vary widely with locality and type of power plant, and they are also changing with time. In this situation a set of druggist's prescriptions for every ailment might do the patients more harm than good. A more constructive approach is to describe pathways toward conflict resolution; here actual case studies can be helpful. The lesson to be learned from these case studies is that each utility will have to devise procedures best suited to its particular situation. These procedures may involve negotiation, arbitration, conciliation, mediation or combinations of these methods. The dominant theme is that full, continuing disclosure of all relevant facts by the utility is essential from the point at which the necessity for a new power plant is established clear through design, construction and operation. In this manner public interest groups have an opportunity to develop and define the issues. The earlier these issues are defined the easier it is to devise an appropriate procedure for the resolution of conflicts.

3.2 Northern States Power Company (Minnesota)

In many areas in the United States there are presently no effective mechanisms for determining environmental factors and taking them into account when considering sites for power plants. Where such mechanisms are either absent or ineffective, it behooves the power company to devise its own mechanism An example of one mechanism developed by a power company is the Citizens Advisory Task Force created by Northern States Power Company. NSP had four available sites for future development at the time it was determined that future generating capacity would be needed by that utility by 1976. This utility found it appropriate to establish a Task Force composed of representatives from local environmental groups in order to determine which one of these sites should be selected for its 1976 unit—a 680 MW(e), fossil fueled power plant.

NSP announced in January 1970 that siting and development of all future plants and transmission lines would be discussed, in advance of decision-making, with the public. To implement this decision NSP went to every major (and some minor) environmental/conservation groups in Minnesota—perhaps some 30 groups. Many of these had been and still are locked in bitter controversy with this utility. Some were small groups, ad hoc groups, others were well established large groups. Each group was asked to send representatives to a Plant Siting Task Force being formed by NSP. The company tried to convey the seriousness with which they were approaching this effort and they asked these groups to send people capable of making the intellectual commitment and willing to make the commitment of time. Not one group refused to participate, although many were hesitant, fearing all of this was just a public relations facade and they would be used by the Company to their disadvantage. But they took the risk and the Task Force was formed with approximately 40 members. During this period much time was spent by utility representatives discussing the whole idea with editorial writers, reporters and opinion leaders.

The Governor of Minnesota had earlier formed an Environmental Cabinet consisting of state department heads (Department of Natural Resources, Economic Development, Pollution Control Agency, etc.). NSP invited participation of the Governor's Environmental Cabinet and they also accepted.

These two groups together with NSP started weekly meetings in March, 1970. Their initial assignment was twofold; first, to make a recommendation to the Company on the location of its next generating station scheduled for service in 1976. The constriction of time required that a recommendation be limited to four sites which the Company already owned. Their second assignment, after completing the first, was to look at the long-range problems of plant siting (including transmission lines) in a totally unrestricted way, and hopefully to develop environmental criteria which the Company could apply in the acquisition and utilization of future sites.

The initial meetings were marked by great suspicion and hostility on the part of everyone. Each week NSP–and in some cases the state–came to take their "lumps". It was "sackcloth-time" and in the eyes of some NSP people it was a futile exercise in masochism. The group included almost every major critic of the Company.

The initial meetings were devoted to a series of presentations intended to bring everyone up to some minimum level of common understanding about the nature of the electric utility business. Whenever possible the Company used consultants, people from the University of Minnesota and other non-NSP experts in the hope of enhancing credibility.

Along about the sixth week, something very significant happened. The group itself turned upon one of the more outspoken critics, and in effect told him to shut up, that they felt they had a chance to do something constructive and that the constant hostility expressed by this one man was getting in the way. From that point on the dynamics of the group began to change.

NSP also learned very early that if a company is to convene a group of this kind, it is impossible to try to limit the areas of discussion. Soon they were discussing things like advertising and marketing policy and expenditures, research, rates and rate structure, validity of demand projections–things that had never been discussed in a public setting and which produced much anxiety for many within the Company. All meetings were open to the public and the press was invited–there were no secret meetings. At least one officer of the Company was present at every meeting. The initial meetings were kicked off by the Chairman of the Board, and he attended other meetings intermittently–all in an effort to express the seriousness of corporate intent. This kind of demonstration is vital because such an effort has great credibility problems with the environmental community.

After a time, the Governor's Environmental Cabinet began to withdraw from the meetings with the Citizens Group, until soon NSP was faced with two separate groups meeting independently of each other. The burdens of staffing these two groups were severe. Any such effort demands complete and total support from all segments of the corporation if it is to succeed. *If a company cannot get that, it should not try it.* Phase one—that is, the effort to reach a recommendation on the location of the next generating unit—resulted in two reports: one from the Citizens Group, and one from the Governor's Cabinet. It did not surprise the pessimists that each report recommended a different location. The Governor's Group recommended a site that had been the Company's first choice initially. NSP had made their own preference clear to the Task Force at the beginning. After a great deal of internal agonizing, the Company elected to follow the recommendations of the Citizens Group. While the reason for that decision is complex, it basically stemmed from the feeling that the rationale presented by the Citizens Group was sounder.

The Citizens Group, through a process of elimination, selected what they felt was the "least of four evils"—the Monticello site near an existing nuclear plant. They eliminated the other sites for the following reasons:

1) **King Site:** This site is located on the lower St. Croix River, which is presently being evaluated by the U.S. Bureau of Outdoor Recreation for inclusion in the Federal Wild and Scenic Rivers System. The St. Croix is one of the most valuable recreational and open space resources in the Minneapolis metropolitan area, and the Task Force did not want another power plant along its shores, even though it would be located next to an existing unit.

2) **Carver Rapids:** This location in the Minnesota River Valley was the only undeveloped site of the four. NSP had recently purchased this site and it was the most desirable from the company's point of view because it had sufficient land to develop a large cooling pond. The Task Force had ruled it out because the site and adjacent properties were being proposed as a state park, and part of the Minnesota Valley Trail will bisect it. The future use and development of the Minnesota River Valley was the subject of considerable public and legislative controversy. The Task Force believed that the building of even a single power plant on this site would commit the area to industrial use and could preclude any long-range study of alternative uses.

3) **Prairie Island:** There are two 550 MW nuclear plants presently being constructed on this site. The effects of their thermal and radioactive discharges

on the environment would not have been known in time to be included in the planning for the emission controls for a 1976 fossil fueled plant; therefore, the Task Force rejected this site for lack of environmental information.

4) **Monticello:** The remaining site, Monticello, is primarily poor agricultural land, and several years of environmental and ecological monitoring studies for the nearby nuclear plant have been completed. Through this process of elimination, which centered primarily around land use considerations, the Task Force selected the *Monticello Site.*

The Task Force continued to meet at a rigorous pace, strengthened by NSP's decision and their belief that this Company is really listening. It has divided itself (by its own choice) into four study groups, each of which will make recommendations to the full Task Force. These four groups are looking at: 1) environmental monitoring programs and research; 2) identification of future plant sites; 3) development and utilization of those future sites; 4) the whole question of future energy demands.

The Task Force mechanism seems to have been effective in this particular plant siting case. A continuation of this process beyond this siting effort will have many obstacles to overcome which could greatly affect the structure and operation of this group in the future. A major negative force acting on this type of volunteer forum is attrition. At the beginning open planning requires a tremendous commitment of time and intellectual involvement on the part of the volunteers who usually have other interests besides the environmental impact of power production proposals. In addition, the major interests of the group convened to help a utility to site and develop power generation and transmission facilities might change to an area of concern which the utility is not as willing to discuss e.g., energy policy and growth. Therefore, power companies will probably find it necessary to change from one mechanism to another from time to time in conjunction with the dynamic properties of conflict over plant siting, energy production and energy consumption. Rigid forums of the past should be re-structured to reflect the needs and dynamics of present and future interactions.

3.3 Consumers Power Co. (Michigan) and Yankee Atomic Power (Vermont)

At the heart of NSP's novel experiment was the concept of full and continuing disclosure of plans from the point of determining required new capacity through the design and operational stages. For the most part this concept may prove more basic to facilitating long-range planning, construction and operation of major facilities than soliciting public participation in the actual planning process.

Given ideal procedures for making public policy with fully responsive and responsible public servants, there would be little cause for public alarm concerning the generation of electric power. The present concern, on the other hand, is partly due to poor planning, the absence of appropriate regulations and the sudden awareness of a dramatic rate of growth within the industry. Bearing this in mind, it is reasonable to expect that until effective mechanisms are devised to facilitate timely and orderly growth, and until the technology exists or is employed to meet society's limits of acceptable environmental impact, social forces beyond those codified by traditional means (governmental agencies, etc.) will continue to bear on problems of power plant siting and construction.

In the case of the Palisades nuclear reactor of the Consumers Power Company on the southeastern shore of Lake Michigan, citizen groups did not actively participate in the planning process. But in the end CPC's response to the social forces bearing on the operation of the plant is quite similar to NSP's.

CPC applied to the AEC for a construction permit for its Palisades plant in 1966. Construction proceeded with little organized opposition until 1970 when CPC applied for an operating license from the AEC. Several citizens organizations appeared on the scene at this point.

The AEC hearings disclosed mounting public opposition to the thermal and radioactive wastes of present and future plants all around the Great Lakes. Anticipating intolerable operational delay, CPC engaged in the co-operative exercise of negotiations.

After several months of negotiations CPC agreed:

(1) to install evaporative cooling towers that were closed-cycle except for cleansing of lake water residues from the towers

(2) to install the latest and most sophisticated containment equipment to eliminate emissions of radioactive wastes.

The agreement is to be enforced by AEC. By this agreement AEC assumes the responsibility of regulating both thermal and radioactive emissions to the agreed upon levels.

The Palisades controversy—quite clearly an adversary process—has had a revolutionary effect on the AEC licensing procedures. The AEC now agrees it is bound to consider environmental effects from other sources than radioactivity when licensing future facilities. In addition, the Palisades agreement sets minimum standards acceptable for all nuclear power plants on fresh water lakes.

The situation any utility finds itself in is essentially unpredictable, as CPC discovered. Opposition came years after initial design and construction stages. The point here is that future engineering and corporate decision-making must be conducted in the context of paradigm change (Section 1.3).

If one can offer any guidance it must by necessity be cautionary rather than prescriptive. Utilities must not attempt to define the public or to set its policies to fixed goals—this is a political and social process that defies analysis in the context of immediately realizable technological alternatives.

Yankee Atomic Power exemplifies this tendency to judge the community narrowly. To facilitate proceedings on an application for a license to operate its Vernon, Vt. nuclear plant, Yankee Atomic sought to define the "public" and bind it by agreement to set issues. The public, however, cannot be defined and while Yankee Atomic may succeed in locking one segment of the public into a "reasonable" posture for purposes of debate, more than likely a dissident faction will intervene and seek judicial review at a later date, further delaying construction and conceivably altering actual design considerations.

The situation illustrates how well-intentioned decision-making and discussion backfires if it begins *after the fact*—that is, after the substantive engineering and corporate decisions have already been made.

3.4 Commonwealth Edison (Illinois)

Just as Consumers Power Company found that design specifications are not sacrosanct, Commonwealth Edison (Illinois) found that even standards, insofar as they embody long-term goals for a specific program of pollution abatement, are subject to sudden change if the public decides against the traditional approaches to setting standards.

Ideally, standards should be set by a rational process based on a clear understanding of the mechanisms to be controlled and with a well-defined and generally agreed-upon set of objectives in view. (See Section 5). But the situation is clearly not ideal owing to rapidly changing priorities and goals.

Commonwealth Edison, which had been seeking an AEC operating license for its Dresden 3 nuclear power plant in Grundy County, Ill., found it necessary to compromise because of intervention on the part of public interest and environmental groups.

The citizens groups intervened before the AEC on the premise that Commonwealth Edison had not complied with recommendations made by the Division of Environmental Radiation, U.S. Public Health Service (PHS) in a review of Dresden 3, as required by the National Environmental Policy Act. The prime recommendation of the PHS was that the radioactive waste system proposed for Dresden 3 be improved to reduce the emissions of radioactive gases.

Although a federal judge had earlier ruled that the state of Minnesota could not legally set emissions standards below those of the federal government, Commonwealth Edison privately agreed to write new standards that provide that Dresden 3, along with Dresden 2 at the same site, emit only *1.5 percent* of the radiation that the AEC would have allowed under its own regulations. The public interest groups in turn agreed to drop their intervention.

3.5 Southern California Edison Co. (Huntington Beach, California)

In order to meet the growing demand for electrical energy in Southern California, the Southern California Edison Co. proposed in 1969 to expand its existing steam power plant at Huntington Beach, California, from a capacity of 880 MW(e) to a total of 2460 MW(e) in three units. After reviewing this proposal, the Orange County Air Pollution Control District determined that such an expansion would increase the daily burden of oxides of nitrogen and particulate emissions in the airshed under its jurisdiction by an unacceptable amount. The APCD, therefore, opposed the application of the utility. The State Public Utilities Commission, on the other hand, approved the application. The case is now awaiting the decision of the State Supreme Court.

This jurisdictional conflict arises because under the state constitution the PUC has ultimate licensing authority over privately owned electric power utilities. State law, however, grants responsibility for setting and enforcing air quality standards to the Orange County APCD*.

Superficially it would appear that Southern California Edison was caught between two *competing* jurisdictions. Actually the utility chose a narrow interpretation of the public interest rather than a broad interpretation. As an example of an alternative procedure, an agreement could have been negotiated with the APCD to derate the plant when ambient NOx pollutant concentration exceeded a certain level.

But whatever the options available at the time, the situation confirms the experience of utilities elsewhere (most notable the cases of Los Angeles Department of Water and Power vs. Los Angeles APCD and Consolidated Edison's controversial Astoria plant) that conflicting jurisdiction is a signal of the ever-expanding nature of regulation. If they are to fulfill their obligation to the public, power utilities must therefore be responsive to changing social priorities by seeking as broad and as open a determination of the public interest as possible.

In the long run it is probably in the interest of electric utilities as well as the public to expose jurisdictional conflicts and to work toward their resolution. Their failure to do so can only contribute to the growing public animosity toward the industry and delay the construction of needed power generation capacity.

*While the final draft of this report was in preparation the State Supreme Court ruled unanimously in favor of the Orange County APCD.

3.6 Alternative Sites of Electric Generating Capacity for California

3.6.1 The Coming Conflict Over New Coastal Sites for Nuclear Power Plants in California

In Sections 3.2-3.5 we discussed conflicts over power plant siting that have erupted in the recent past, and have either been resolved, or are (hopefully) in the process of being resolved. Now we turn our attention to a conflict that lies just ahead—the siting of nuclear power plants at new, remote locations along the California coast. The major private and public electric utilities in California are attracted to these sites for the following main reasons:

(1) difficulties experienced in meeting air quality standards on SO_2, NOx and particulate emissions with fossil-fuel plants located close to urban load centers;

(2) stringent new air quality standards on large coal-fired inland plants in New Mexico, Nevada, Arizona and Utah,* court suits against these plants by environmentalists, and environmental impact studies by the Department of the Interior;

(3) remoteness of these coastal sites from high-density population zones, as required by radiation criteria in event of "accidents";

(4) access to "unlimited" supply of once-through cooling water;

SCE has announced its intention of building a new, large nuclear power plant at Point Conception (about 40 miles west of Santa Barbara), and Pacific Gas and Electric Company is examining sites for large nuclear power plants at Davenport (about 10 miles N.W. of Santa Cruz), and at Point Arena in Mendocino County. Some environmentalists see a vision (nightmare?) of a whole series of nuclear power plants sited along the California coast in the next 10-20 years at all of the most beautiful and remote wilderness locations. Thus the drive toward the coast by the electric power utilities is on a collision course with the leading environmentalists and other public interest groups. For example, in its proposed State Power Facilities Siting Council Act (1971) the Sierra Club states:

*Desert power plants now in operation are located at Fruitland, N.M. (2150 MW(e)) and Mohave, Nevada (1600 MW(e)). Page, Arizona (2300 MW(e)) is under construction and Kaiparowits, Utah (6000 MW(e)) is in the planning stage. Original plans by a consortium of 23 Southwest utilities (Western Energy Supply and Transmission Associates) called for a total of 36,000 MW(e).

> "The coast of California is an area of unique value to all the people of California. No power plants or transmission line facilities shall be built in the coastal zone wherever it is presently free of the encroachment of major industrial, commercial or residential development."

Here we have an almost "classical" case of a failure on the part of the major electric utilities to involve the public interest groups in meaningful planning operations and in the search for viable alternatives (if any) right from the outset. The approach used so far is to announce the possible new site locations and then to solicit the "reactions" of citizen groups. However, it is certainly not too late to experiment with various mechanisms of conflict resolution. In the following sub-sections we discuss briefly only a few possible alternatives to new coastal sites for nuclear power plants. The objective here is not to offer a set of technological "fixes", but to show how a useful discussion could be opened up between the major electric power companies, members of the legislative and executive branches of State government, and interested citizen groups. No one can possibly predict the outcome of such a discussion, but the outcome might well be preferable to the impending conflict over coastal siting.

3.6.2 Southern California

3.6.2.1 Expansion at Site of Existing Nuclear Plant

Southern California Edison and San Diego Gas and Electric are already well along with their planned expansion of the nuclear facility at San Onofre (near San Clemente) by 2300MW(e) by 1976. The question naturally arises as to a *second* expansion at or below San Onofre. Such an expansion [say, by an additional 2300MW(e)] would require agreement by the appropriate Federal agencies for the use of land presently included in the Camp Pendleton (U.S. Marine) area. The city of Oceanside (population about 40,000) lies about 14 miles below San Onofre, so no difficulty would be experienced with the AEC population zone criteria on that score. Planning would have to include preservation and even enlargement of the present beach area. (The new units might have to be located on the inland side of Interstate 5).

Open planning or other mechanisms might also lead to a significant change in the method of waste heat disposal utilized at this site. Present thermal discharge practice employs a small number of large outfalls located near the surface. Large heated ocean surface areas are produced downstream of the outfalls, and most of the waste heat is transported to the atmosphere by radiation and convection. An alternative method has been employed previously by Dr. Norman Brooks of Caltech to inhibit and even prevent the effluent discharged from sewage water plants from rising to the surface. Dr. Brooks designed a series of multiport diffusers that discharge out to sea under the thermocline. As the effluent (or warm water in our case) rises, it mixes with the surrounding denser fluid, gradually loses its buoyancy, and eventually reaches a "stable depth". By proper design almost any desired dilution ratio and stable depth can be achieved. Multiport diffusers for handling thermal power plant discharges would probably have to be arranged at various depths in a vertical array in order to entrain the volume fluxes of ocean mixing water that are required to bring the excess temperature down to a small value (say, 1 degree Fahrenheit).

Another method is to reach out farther and deeper into the ocean for cooler intake water, so that the difference between discharge water temperature and ambient water temperature is reduced. Conceivably, the nutrients contained in the discharge water, when properly oxygenated by mixing with surface water, could form the basis of a sizeable local sea food industry.

The objective of these two alternative methods is to avoid local "hot spots."

3.6.2.2 Use of Municipal and/or Industrial Waste Water for Evaporative Cooling at an Inland Site

Because of the scarcity of water of the required quality in the inland areas of the Southwest, imaginative schemes for the reuse of waste water need to be developed. A number of interesting possibilities are opening up because of the current drive in the U.S. to provide secondary (and even tertiary) treatment of waste water. In Las Vegas, Nevada a fossil-fuel electric power plant is utilizing treated municipal waste water in evaporative cooling towers. A proposal for the large-scale use of treated waste water for evaporative cooling in Northern Central Texas (Dallas-Ft. Worth area) is now under consideration by a group of electric utilities.

The logic behind this development for the Southwest is easy to understand. Modern urban areas in the U.S. utilize water for all purposes at the rate of about 200 gallons per day per capita. About one-half of this amount, or 100 gallons/day/capita, could be recovered and reused, corresponding to a latent heat of 220 kwh/day/capita. But the use of electric power for all purposes amounts to about 20 kwh/day/capita, and the corresponding waste heat rejection at the power plants at 30% overall efficiency is about 47 kwh/day/capita. Thus we need to divert about 22% of the potential amount of reuseable waste water to power plants using wet, evaporative cooling towers, if this water is the sole source.

A major problem with the reuse of waste water is that most of the municipal waste water is located in urban areas, whereas nuclear power plants must be located far from regions of high population density. In some cases, it may be advantageous to pipe treated municipal waste water from large urban areas near the ocean, such as Los Angeles, to remote inland sites 100 miles away. An economic analysis is required to determine capital and operation costs of such a scheme.

3.6.2.3 Lake Powell Area and the Kaiparowits Plateau

Lake Powell (Utah) is a large, man-made lake 252 square miles in area that was created by damming the Colorado River at Glen Canyon Dam. The attractiveness of this water supply and the abundance of coal has already brought a coal-fired power plant to Page, Arizona (just south of the southwest tip of Lake Powell), and a second fossil-fuel plant is planned on the Kaiparowits Plateau north of the southwest tip of the lake. A substantial fraction of the power generated at these plants is assigned to the Southern California Edison Company and the San Diego Gas and Electric Company. However, these plants, and the proposed expansion of the coal-fired Four Corners Plant in northwest New Mexico, raise serious environmental problems that are presently the subject of a year-long environmental impact study by the Department of the Interior. This power complex, and the Black Mesa coal supply, are also being challenged by a coalition of environmentalist groups, and the controversy is apparently headed for the courts.

The question naturally arises: why not build a nuclear power plant of 6000MW(e) capacity on the Plateau near the planned location of Kaiparowits? Such a plant would require about 220 cubic feet/second of evaporative cooling water from Lake Powell, or about 100,000 acre-feet/year. This requirement should be compared with the capacity of the lake, which is about 27,000,000 acre-feet. In fact, estimates of its capacity from several different sources vary by about 1,000,000 acre feet!

Eventually a second nuclear power plant of similar capacity could be constructed on the Plateau. These two nuclear plants plus the coal-fired plants at Page and Kaiparowits would dissipate about 40,000 MW of rejected heat energy into the desert atmosphere over an area of about 1000 square miles. By comparison about 90,000 MW of thermal energy from all sources (1971) is dumped into the air above the L.A. basin over a 1500 square mile area. Convective wind currents should keep the ambient temperature rise down to a *maximum* of 2-3 Fahrenheit degrees.

A nuclear power plant located on the Kaiparowits Plateau would not be plagued by air pollution problems, by huge, unsightly piles of coal and by coal supply and transport problems. Because of its remote location, radiation standards for the "maximum credible accident" should not be difficult to meet. If a second large nuclear power plant were located in the same general area it might be possible to adopt Dr. Alvin Weinberg's suggestion of a local fuel reprocessing plant servicing this "nuclear park", thus eliminating the problem of long-distance transportation of radioactive wastes from these plants.

A very rough cost analysis of a nuclear power plant on the Kaiparowits Plateau shows that the system costs (including transmission lines and substation) would be about \$500/KW(e), compared to about \$360/KW(e) for a fossil-fuel plant on the Plateau. If this increase of about 40% in capital costs is applied to the whole Southern California power system the consumer would experience about a 7½% increase in electric power rates.

3.6.2.4 Use of Dry Cooling Towers in the San Joaquin Valley

Experience with dry cooling towers for thermal power plants is minimal in the U.S. However, in Western Europe a dry cooling tower has been built for a plant as large as 120 MW(e) capacity. Until recently there was no reason to employ this method of waste heat management in the U.S. Increasing controversy over the environmental impact of coastal power plant sites may make certain inland sites look much more attractive. In some of these areas, for example the lower (S.E.) end of the San Joaquin Valley, "natural" water is scarce and municipal or industrial waste water flow is not adequate for evaporative cooling of a large power plant.* Thus, if dry cooling towers for plants of 1000 MW(e) capacity (or larger) could be developed, certain inland sites would be opened up that are now out of the question.

For large power plants the most attractive type of dry cooling tower is the "indirect" or Heller system. In some respects, the Heller tower is like a gigantic automobile radiator. The usual car radiator dissipates about 70 HP, or about 50 KW, while the Heller towers would dissipate about 2000 MW for a 1000 MW(e) nuclear plant. The factor of 40,000 in energy means a factor of 40,000 in radiator area (roughly), or a factor of 200 in linear dimension.

One of the problems with the dry cooling tower is that the condenser discharge water operates at much higher temperatures than in the case of once-through cooling, or wet evaporative cooling. For example, summer temperatures of 100 degrees are experienced in the San Joaquin valley, so the condenser discharge water would circulate at a temperature of 150-160 degrees. Corresponding turbine back pressure would be at least 15 cm Hg, and the last stage of American steam turbines for power plants would have to be redesigned to avoid excessive loss in turbine efficiency.

Overall costs will be higher than for the system employing wet evaporative cooling. Nevertheless it would be worthwhile to explore this possibility in some detail for a site near Bakersfield (about 100 miles from Los Angeles).

*Agricultural drainage water in the San Joaquin Valley is a possible source of water for wet evaporative cooling towers.

3.6.3 Northern California: The Sacramento Valley

At least one large power plant in Northern California, constructed by the Sacramento Municipal Utilities District (SMUD) near that city, uses evaporative cooling towers. The average annual water flow in the Sacramento River along a 150-mile stretch from Redding (below Shasta) to Sacramento is 10,000 cubic ft/sec., and the flow rarely drops below 8000 cubic ft/sec. Nuclear or fossil-fuel plants using evaporative cooling towers could be located in the Sacramento Valley on both sides of the river. As mentioned earlier, a 6000 MW(e) nuclear plant requires about 200 cubic feet/sec. of evaporative cooling water—a small fraction of the Sacramento River flow. Of course, water rights for this amount of water would have to be purchased through the California Water Plan.

3.6.4 Off-shore Siting

Opposition to new coastal sites and increasingly difficult problems of land use and waste heat management in inland areas make off-shore siting of nuclear power plants look more and more attractive for the 1980's. In fact, recent public statements by Mr. Charles Luce, chairman of Consolidated Edison of New York, and Mr. Elwood Eberle, president of Public Service Electric & Gas Company of New Jersey, show that off-shore siting is an idea whose time has come. The Special Projects Division of Westinghouse, Pittsburgh, Pa., is working independently on the concept of a barge-mounted nuclear reactor that would float on the sea in about 200 feet of water about 2-3 miles off the northeast coast of the U.S. This concept has the advantage of shipyard construction and standardization. During the next 6-8 months the Caltech Environmental Quality Laboratory will conduct an intensive feasibility study of several different concepts, with special reference to the requirements of California.

4

ECONOMIC ASPECTS OF ENVIRONMENTAL CONSTRAINTS ON POWER PLANT SITING

4. *Economic Aspects of Environmental Constraints on Power Plant Siting*

In Section 1.2 we emphasized that providing for the energy needs of society and minimizing adverse environmental effects must be co-equal objectives. In Section 1.3 we emphasized that these twin objectives must be achieved at minimum cost; otherwise, "agreements" between the electric power companies and the environmentalists are achieved at everybody else's expense. At the same time, it is important to put "costs" into proper perspective. Too often the phrase "too costly" has been a cover-up for inertia. People are now quite rightly asking, "too costly compared with what?"

Obviously the economics of electric power plant siting under environmental constraints is a very complex subject, involving energy costs as a percentage of manufacturing or living costs, price-elasticity of electric power demand, substitution of other, competing forms of energy that create more (or less) pollution per KW, etc. The situation is not made any easier by the absence of any meaningful cost-benefit analysis (if such an analysis is even possible). In spite of these difficulties it might be helpful to examine a specific example of the impact of environmental constraints on electric power costs to the consumer.

Suppose that after considerable study an electric power company and a citizens advisory task force jointly decide that a new power plant should be located some 300 miles from the load center, and must use evaporative cooling towers. Roughly speaking, the increased capital costs over costs for a plant near the load center using once-through cooling are as follows:

<u>1000 MW(e)</u>

Item	Capital Cost (1971 Dollars)	% of Plant Cost	% of System Capital Cost
Evaporative Cooling Towers	\$20-\$25 M	8-10	5-6+
300 Mile Transmission Line at \$150K/Mi. (500KV-A.C.)	\$45 M	18	11+
Sub-Station (Additional)	\$20-\$25 M	8-10	5-6+
Totals	\$85-\$95 M	34%-38%	21%-24%

In this example the basic plant capital cost is taken as \$250/KW(e), and the system capital cost, including plant, transmission and distribution, is taken as \$400/KW(e).

In addition, increased operating costs will be incurred because of power required for pumps and mechanical draft, slightly reduced turbine efficiency, etc; these cost increases are estimated at roughly 12%.

Now what is the impact of these increased costs on electric power rates to the consumer? A typical breakdown of one dollar's worth of electric power delivered to the customer is as follows:

Fuel and purchased power	20¢	24¢ production
Other production expenses	4¢	
Transmission	4¢	11¢
Distribution	7¢	
Customer accounts, sales, administrative and general	11¢	
Dividends	11¢	37¢ capital
Depreciation	12¢	
Interest on debt	10¢	
Re-invested in business*	4¢	
Taxes	17¢	
	100¢	

By applying the appropriate factors to the increased capital and operating costs for the new power plant we obtain the following results:

Capital Costs:	(21%-24%) x 0.37	=	8%-9%
Operating Costs:	12% x 0.24	=	3%
	TOTAL		11%-12%

Thus the increased cost to the consumer is around 12%, or about 2.6 mills/KW hr. at a residential rate of 2.2 cents/KW hr.

*Actually an additional 3% is retained, but these funds come from "other income," such as interest charged to construction.

A typical yearly cost of electricity for a "standard" home is about $125, or about 1% of median family income in California. For all manufacturing, the energy bill amounts to an average of about 3.5% of manufacturing costs, whereas in certain specialized industries the energy costs are 10%, and in non-ferrous metals as much as 25% of manufacturing costs. For commercial customers the electric power bill is only a few percent of total business expenses, including rent and labor. Thus, one strongly suspects that electric power demand is "price-inelastic" and "income-elastic", except for certain important special cases.

Of course the problem is not quite this simple, because rising fuel costs are contributing to increases in power bills at the same time, and some of these increased costs are attributable to environmental constraints. Nevertheless, the increased electric power costs directly attributable to power plant siting and waste heat management do not appear to be excessive.

Clearly, this complex question needs to be studied much more carefully, and separately for each specific case, including relative fuel costs of uranium and fossil-fuels. comparisons between various siting alternatives, impact of rate increases on low income groups, relation between demand and the rate structure, etc.

5

TRENDS IN REGULATION AND STANDARDS

5. *Trends in Regulation and Standards*

The electric power industry has been a regulated industry for a very long time. Originally the regulation was concerned mostly with safety, rate setting, and corporate structure. More recently, regulation has been increasingly concerned with reducing adverse environmental impacts, and the amount of that regulation is increasing rapidly. This increasing regulation, coming at a time of rapidly increasing power demand, is having a disruptive effect on the electric power industry. This section considers some aspects of regulation, particularly environmental regulation, and suggests an approach to minimize disruption while permitting the development of urgently needed environmental control. There are definite signs that the system of regulation is developing in the direction suggested.

Standards are the basic tool of regulation. They embody the criteria of performance with which a regulated industry must comply. Ideally, standards should be set by a rational process based on a clear understanding of the mechanisms to be controlled, and with a well-defined and generally agreed-upon set of objectives in view. Once set, the standards should change slowly if at all, and then only in an orderly and deliberate way. To facilitate the wide applicability of specific technology, it is very desirable that the standards be applicable to a wide geographical area, the whole United States if possible. Safety standards and technical standards tend to approach the ideal rather more closely than some other kinds of standards.

In the specific case of environmental control, the customary approach to setting standards is being abandoned for what appear to be three related reasons:

1) a large part of the public is alarmed by the deterioration in the environment and is unwilling to await good understanding in an area that is very difficult to understand very well;

2) long experience with air and water quality standards, while satisfactory in some areas, has been disastrous in others because of the lack of enforcement and/or compliance;

3) the public realizes that once a power plant has been built it is very difficult to do anything fundamental to it and essentially impossible to remove it if it turns out to have been a mistake.

Behind these three reasons there is an intuitive feeling that we are in a situation of such rapid growth and change that it may never be possible to set standards by any rational process based on any reasonable degree of understanding of the mechanisms of environmental damage. Because of this feeling, the public is resorting to the political process to set standards rather than to the traditional processes, and to the courts to enforce them (if necessary) rather than to the traditional regulatory agencies.

Recognizing the current use of the political process and the courts, many people in the electric power industry are appealing for a return to "rationality" in setting standards and in regulation. *This appeal misses the point that the public has decided against the traditional approach. The problem now is to learn how to provide needed power within this new set of constraints.* One part of a solution to this problem is addressed in Section 2. Another part having to do with standards and regulations *per se* is addressed below.

One important point that must be recognized in trying to cope with environmental standards is that these standards are being used for several quite different purposes. One purpose is to embody long-term goals. A reasonable expression of a proper long-term goal for air quality is that air should not contain any man-made pollutant at a level which would be injurious to health or welfare. A similar statement can be made concerning water quality goals. Such a statement does not mean that the air or water might not contain *some* level of man-made pollutants. The actual level which should not be exceeded in order to meet the goals is set forth in an *ambient air* (or water) *quality standard.* (The term used here to describe the several kinds of standards is somewhat arbitrary, but is in general consistent with legal usage and usage in the literature.) Such a standard is set to reflect the best understanding of the effects of pollutants on man's health or welfare, including effects on plants, animals, and property. They will change as our understanding changes and, in case of doubt, are more, rather than less, stringent. Considerations of technical or economic feasibility do not enter into the setting of this class of standard. The situation here is somewhat analogous to the setting of standards for adequate human nutrition which are based on considerations of human health and well-being but are known to be unattainable for a large proportion of the earth's population. It should be noted that such ambient air or water quality standards are generally applicable nation-wide, since they apply to people, not the situation in which they are living.

A second kind of standard embodies short-term *regional* goals. These standards have been termed *management standards* and are interim standards which embody technologically and economically achievable levels of ambient air or water quality. They are typically set to embody the goals for a specific program of pollution abatement within a well-defined geographical region selected because its air or water resources are best managed as a unit. As such, they have associated with them definite dates for attainment. To the extent that they fall short of the ambient air quality standards they are subject to revision as new programs of abatement based on new technological and economic resources are devised. New ambient air or water quality standards may also trigger the setting of new management standards. The key factor in management standards is that they are intended to be realistic compromises between environmental, economic and technological forces and attainable at a designated time.

The third kind of standards are *emission standards.* These are standards which are set to establish permissible levels of pollutants in emissions from the various sources of pollutants. Ideally, emission standards should be set on a regional basis as part of the same program that sets management standards for that region. At present the delegation of authority for setting emission standards is different in different states, and the Federal government has preempted some of the authority. However, except for motor vehicles, there is a definite trend toward setting emission standards on a regional, rather than state, national or local level.

An important kind of interaction between the management standards and the emission standards involves the measurement of the actual air or water quality. The idea is that if the actual air or water quality improves in some respects, the stringency of the corresponding emission standards can be relaxed, and conversely, if the actual air or water quality worsens, the emission standards can be tightened. This kind of interaction is particularly effective in handling seasonal variations. An outstanding example is the regulations in Los Angeles that permit the burning of oil in power plants during certain seasons but require natural gas (or low sulfur fuel oil) in others. The system that regulates the use of the Ruhr River in carrying away wastes is similar even though it uses a scheme of fees rather than prohibitions as a control mechanism. It should be noted in passing that a properly designed system of air or water use fees is an effective method of "internalizing costs" as well as controlling ambient air or water quality. Such fees may often be a more effective and faster method of control than prohibitions. They are also more flexible and conducive to necessary experimentation. Under proper administration they cannot be considered a "license to pollute".

A particularly painful interaction between management and emission standards occurs in cases where currently achievable emission standards result in unacceptable levels of pollutants under specified conditions. One example is the problem of waste water discharge into a stream or river under drought conditions, when the flow rate is much lower than normal. In this case all or part of the discharge is diverted to an empondment or canal until stream or river flow rates return to normal. In extreme cases plant operations may have to be curtailed or even suspended. Another example is the occurrence of low inversion layers or stagnant air conditions in urban areas. An effective "smog alert" based on strict adherence to management air quality standards would involve limitations on the use of automobiles and the "de-rating", or even closing, of power plants and industrial sources of pollution until atmospheric conditions improve.

There are, of course, exceptions to the structure of standards described here, and there will always be exceptions even if this scheme becomes well understood and widely adopted. Some of these will be in response to public pressure. For example, if the public feels that an industry is too large and powerful to be responsive to local authorities, there may be instances of state or even national emission standards. Indeed, we already see some of these. Nevertheless, it is to the advantage of the public and to the power industry to have a system of standards like the one described above rather than national emission standards, in most cases. There is, however, a natural relationship between national, state, and local standards that is compatible with the structure of standards described. It seems quite appropriate that the federal government set overall ambient air and water quality standards. The states, either singly or, when required, in concert, set up the general programs of establishing air and water regional authorities with the responsibility for establishing both management and emission standards. In some cases the states would be permitted to set more stringent standards (but not less stringent standards) than the Federal government. Each level is subject to review by the higher level or levels which coordinate the efforts of lower levels and stand ready to provide technical assistance or even take over faltering programs. Such an approach appears to assure the most rapid possible abatement of pollution for the country as a whole, and for each region as well.

This approach is not simplistic, and for that reason will be somewhat difficult to explain and justify to the public. The power industries can help in the process, but only if the public is convinced that they have a full commitment to pollution abatement, and are not trying to use a complex system to avoid doing their very best. It will be in the best interests of the power companies in the long run to have a hand in setting standards, and to have the standards set considering technical and economic feasibility. To that end it behooves the power companies to in fact do their very best in abating pollution and to be perfectly open about their difficulties and limitations as well as accomplishments. They should never be in the position of hiding behind an emission standard when the actual air or water quality fails to meet the ambient air or water quality standards.

Although there are definite indications that the United States is developing a workable system for assuring air and water quality along the lines described here, there are other areas of public concern related to power plant design and siting for which no effective system for considering the public interest appears to be developing. Among the more important of these areas are land use and resource use and allocation. For example, much of the opposition to specific power plants has been concerned with land use rather than emissions. Although there is a great deal of legislation pending about land use, especially along shorelines, there is no indication of an overall system for handling the general problem of land use.

The situation with respect to the allocation and use of natural resources, particularly energy resources, is perhaps even less developed than for land use. Certainly the availability of fuels of various kinds has a major effect on the design and siting of power plants. In a given situation, the use of a particular fuel might make the difference between acceptability and unacceptability for power plants. Yet no method presently exists for allocating fuels among various users in any general way. It seems inevitable that the public interest will demand some better method than the present *laissez faire* method, but none appears to be evolving.

6

UNRESOLVED PROBLEMS OF DEVELOPMENT AND RESEARCH

6. Unresolved Problems of Development and Research

6.1 Need for the Development of New Technology

Increasingly stringent standards of air and water quality and increasing public concern over possible radiation hazards connected with nuclear power production are driving the electric power industry to seek new technology to control or minimize the adverse effects of electric power generation on the environment. However, this search for new technology is severely hampered by the fact that the public and private power companies usually do not carry out their own research and development. Traditionally, they write the specifications and rely on the equipment and component suppliers to perform the research and development required to meet these specifications. Because there are literally thousands of utilities in the U.S., and many equipment or component suppliers, the whole development effort is fragmented. Unlike the communications industry, there is no equivalent of the Bell Telephone Laboratories, or Western Electric.

Although the system for creating new technology utilized by the electric power generation industry may have worked reasonably well in the past, it is becoming increasingly evident that it is wholly inadequate to meet the unprecedented demands of the 1970's and 1980's. To be more specific, consider briefly five main areas in which the development of new technology is essential if growing energy demands are to be met, at the same time that adverse environmental effects are minimized: (1) Reduction of adverse effects of fossil-fuel plants on air quality; (2) Development of beneficial uses of waste heat; (3) Reduction or elimination of radiation hazards; (4) Development of new energy sources; (5) Development of novel methods of power plant siting.

(1) Air quality:

The three major pollutants emitted from fossil-fuel burning power plants are oxides of sulfur, particulates and oxides of nitrogen. Without minimizing the importance of the last two pollutants, the most serious problem nation-wide is the suppression of sulfur oxide emissions. Obviously, there are two possible paths towards the solution of this problem: (a) treatment of stack gases, (b) use of "zero-sulfur" or "low-sulfur" fuels, or fuel processing to remove the sulfur content of ordinary fuels before combustion.

Attempts to remove the oxides of sulfur from the stack gases by means of alkali "scrubbers" or by catalytic oxidation have not been too successful. The large volumes of stack gases and the low final concentrations of oxides of sulfur presently required make these processes inherently difficult. The problem is not made any easier by the fact that emissions standards are bound to become even more stringent in the future in order to meet management air quality standards in urban air basins.

Supplies of low-sulfur fuel oils are falling behind demand and prices are rising rapidly. In many cases it is becoming potentially more attractive to remove the sulfur from ordinary fuel oil before it is burned. A similar process can be used with coal, but substantial removal of the sulfur is difficult because of the physical and chemical structure of coal. This difficulty can be overcome if the coal is converted to a liquid or gaseous form. This approach has the additional advantage of reducing the magnitude of the particulate emissions problem by discarding the solid ash before burning.

The work of the Coal Research Board has resulted in a process for the liquefaction and desulfurization of coal, and a consortium of large oil companies is building a pilot plant for Dynaelectron Corporation's Hydrocarbon Research, Incorporated. The major gas companies, through the Institute of Gas Technology, are operating small pilot plants for the hydrogassification of coal. However, in remarks delivered recently at the NAE-COPPS Forum, Dr. Osborne, Director of the U.S. Bureau of Mines, estimated a date of "1980" for the first large scale production of desulfurized fuel by either of these processes! This time-table is incompatible with the urgent needs of the electric power industry and is ridiculously slow for an industry with a gross income of at least $20 billion in 1970.

Natural gas, or methane, is the "zero-sulfur" fuel utilized for many years by power plants in Southern California. The growing demand for methane all over the U.S. and the static or declining supply creates a need for conversion of other, more plentiful hydrocarbons to methane. Coal is one possibility, but another source that might be developed more quickly is the light fraction of petroleum with boiling points below the boiling point of gasoline. The process is feasible on a small scale, but here again large-scale development work is urgently needed.

The whole question of fuel conversion has implications that go far beyond the needs of the electric power industry. The demand of the U.S. for oil for all purposes is increasing at the rate of about 5% per year. Domestic production will fall farther and farther behind requirements over the next 20 years, even if the best estimates of the Alaskan reserves are included in the forecast. On the other hand U.S. coal reserves are estimated at about 400 years supply at current production rates, so the conversion of coal to liquid (or gaseous) hydrocarbons may become competitive with oil imports as the price of imported oil rises steeply. Coal conversion may maintain a competitive advantage even when the costs of giving proper attention to the preservation of topsoil and the restoration of the land are included in the cost of coal mining operations.

(2) Beneficial uses of waste heat:

If cold deep ocean water is utilized for power plant cooling, the nutrients brought up from the depths and then discharged back into the ocean at the surface could be employed as the basis for a new industry called "mariculture". Experiments are being carried out on the use of warm thermal discharge water for the biochemical treatment of sewage waste water; the warm discharged water promotes the growth of algae, which extract nitrates and phosphates from the waste water. The algae can be sold as protein for animals. Many other examples of "aquaculture" would undoubtedly be developed, and rather quickly, if there were a centralized development agency to promote this work.

(3) Radiation hazards:

Promising methods exist for the treatment of solid and liquid radionuclides at a nuclear power plant that would virtually eliminate the necessity for discharging any of these substances into the environment. If successful, these techniques would reduce the discharge of radioactive substances by factors of 50-100.

Another problem that will become troublesome in 5-10 years is the discharge of gaseous Krypton-85 from atomic fuel processing plants. By the use of liquid nitrogen cold traps and activated charcoal filters, Kr-85 could be liquefied, removed, and stored under pressure (half-life is 11 years).

At present the AEC has the responsibility for some of these matters, but the electric power generating industry "takes the heat" at public hearings and in the press. The industry itself will have to take over the development effort in this area.

(4) New energy sources:

At present approximately $100 million/yr. is being spent by the AEC on the development of fast breeder reactors of various types, including the liquid sodium reactor. This sum is about one-half the amount being spent on the development of the new U.S. Air Force B-1 bomber in its early phases.* It is hardly surprising that the estimated date for the practical utilization of the FBR is 1985!

An infinitesimal amount of time and money is being devoted to the development of practical means for the utilization of solar energy, including solar-heated homes, photo-voltaic cells on a large scale and at competitive cost, etc. Yet the use of virtually pollution-free solar energy is one of the very few ways that have been suggested to limit or control man-made heating of urban atmospheres—a problem that will certainly require attention in the post-1985 time period. Work on the development of geothermal power is also proceeding on a rather leisurely time-scale, in spite of its obvious importance for local regions of the West and Southwest U.S.

Fusion research seems to be progressing very well under the control of the AEC, although this work could also be accelerated somewhat by doubling the current sum of $25 million/yr. devoted to it.

(5) Novel methods of power plant siting:

The electrical power generation industry is already encountering severe difficulties in obtaining new power plant sites, and these difficulties will be compounded as the demand for electrical energy grows (Section 1.1). New methods of power plant siting will have to be developed, including offshore floating or shallow-submerged nuclear power plants (Section 7); siting on marginal agricultural land using piped-in, reclaimed waste water for evaporative cooling, or "dry" cooling towers; long-distance transmission to load centers using cooled low-resistance lines, etc.

*We are not taking any position for or against this new weapons system; we are merely drawing useful comparisons.

6.2 New Mechanisms for Development and Research

A large, integrated, and well-directed research and development effort will be required in order to make certain that the more than 250 billion dollars that will be invested in power generation equipment over the next twenty years will produce a power generation system that meets the nation's need for electrical power and contributes to the improvement of the environment. It must also insure that the development of new fuel sources and treatment methods will serve the other major energy uses, for example heating, manufacturing, and transportation, as well as electric power generation. Two different paths could be followed in organizing such a large-scale development effort: (1) establishment of a new Federal agency, which might be called the National Energy Administration (NEA); and (2) establishment of a new energy development corporation by a consortium of private (and public?) power companies.

The new Federal agency (NEA) would be an independent executive agency established by an act of Congress. It would be similar to NASA in concept, but not necessarily in structure. It would have to be given a clear mandate and an adequate funding; the amount required could easily be provided by a very small tax on energy use. At the present rate of consumption in the United States a tax of only a half mill per kilowatt hour on electrical energy alone would produce more than three-quarters of a billion dollars per year. A definite "life-time" for this new agency might be established of (say) three years; each year the Congress and the President could review the work of the NEA and decide if it should be continued for another three years, or phased out over the next three years.

A number of political obstacles would have to be overcome in order to bring the NEA to life, and delays of 3-5 years in establishing such an agency would be costly. An alternative procedure is to establish a private Energy Development Corporation (EDC) under the control of a consortium of the large energy producers in the U.S. Possibly it would begin with the electrical power generating industry, but the importance of natural gas and desulfurized fuels would undoubtedly bring in other segments of the energy industry. Legal problems and problems of including assessments for the EDC in the public utility rate structure would arise, but do not appear to be insurmountable.

The need for new technology for power generation and fuel treatment is so great that unless one of these two possible agencies is created, and soon, we are quite likely to be both short of energy and living in a poorer environment in a very few years.

7

LONG-TERM PROSPECTS

7. *Long-term Prospects*

In the long term, say beyond 1990, the problems of power plant siting in the United States will be somewhat different than for the more immediate future. The problems then will probably be conditioned by three major factors: the population will be substantially larger than now, the per capita consumption of power will be several times as large as now, and the population will be more concentrated than now in both a relative and an absolute sense. It appears that the population, and hence the electric power load, will be concentrated along the east coast, the west coast, around the great lakes, and along the gulf coast. In this situation the problems of power plant siting for the plants which will supply most of the load will be similar to the problems for the plants which now supply New York and Los Angeles. In these two areas there is already a clear trend toward importing power from other areas, often a considerable distance away.

Although it seems likely that the trend to remote siting of power plants will be well developed by 1990, the criteria for selecting the remote sites will be somewhat different for fossil fuel plants and for nuclear plants. The fossil fuel plants will need sites that allow the transportation of fuel, mostly coal or a coal derivative; the disposition of ash and possibly scrubber effluent, some means of cooling, and provision for transmission lines to the load. If present trends continue, sites on bodies of water, including rivers lakes, estuaries, and the ocean, and in wetlands will be unacceptable. This trend will force the use of closed-cycle cooling and permit siting on marginal agricultural land. There appears to be an adequate supply of such land, since a large power plant requires only 1000 to 3000 acres, so that even a hundred large plants would require only 300,000 acres out of some 300,000,000 acres of agricultural land. Moreover, we have a long-term program of reducing the amount of agricultural land in production, and this program is likely to continue. It seems reasonable that, with proper control of pollutants, the power companies will have a large number of sites available to optimize the trade-offs between fuel transportation, waste disposal, and transmission lines.

The natural supply of clean fuels like natural gas or light, sulfur-free oils is becoming very limited. Indeed, the great supplies of fossil fuel energy in the United States are in coal and oil shale. Neither of these is an ideal fuel. So far only coal is used on a large scale, and its use leads to severe problems of fly ash and sulfur dioxide removal from the stack gases. It is becoming more evident that the desired approach to the use of coal is a two-step process in which the coal is processed to produce a light hydrocarbon for use as a fuel and the undesirable components never enter the combustion process at the power plant (Section 6). The disposal of the undesirable components is a problem; perhaps the best approach is to return them to the mine. If oil shale is developed as an energy source it is likely that a two-step process will be the natural approach. The undesirable component is even larger (the shale) than for coal and the return of it to the mine seems an obvious approach.

The problems of siting a nuclear power plant are somewhat different than for a fossil fuel plant. The whole problem of handling the fuel and disposing of the waste products is not very dependent on the distances involved. For that reason the fuel transportation and waste disposal drops out of consideration in choosing a site. The transmission lines are just as important as for a fossil fueled plant in an absolute sense, perhaps more so in a relative sense. Cooling is more important because of the lower thermal efficiency. Safety is of paramount importance. Safety under normal operation is not likely to be a problem. The standards for radioactive effluents are low and are going down rapidly. In a few years they may well be so low that even operation in a high population area would be acceptable.

Accident safety is another matter. There is great public trepidation about the possibility of the accidental release of large amounts of radioactive materials. It appears inevitable that large exclusion zones around each plant will be required in which there will be permitted no permanent residents or commercial or business activity, and only low density transient occupation. A further restriction on the siting of nuclear power plants in the west coast area of the United States is the need to protect them from the effects of earthquakes. Only certain geological area are suitable.

Given these factors, particularly the safety factors, an obvious location for nuclear power plants is the deep water offshore in the oceans and in the middle of the larger of the great lakes. This location would provide an essentially unlimited supply of cold water for cooling, which could be discharged at a temperature at or below the surface ambient to minimize the impact on the environment. In fact, the effect might be beneficial in bringing nutrients to the nutrient-deficient surface waters. In many cases the length and cost of transmission lines to the load centers would also be less. Of course, an exclusion zone is automatically provided if the power plant is more than twenty-five or thirty miles offshore, and the deep water would effectively insulate a floating hull from earthquake waves.

The factors which make the deep water offshore an attractive location for nuclear power plants may in some cases make it an attractive location for a fossil fuel burning plant. For example, an oil-burning plant constructed in a floating hull forty miles from the load center and using cold deep water for cooling might be more economical than the same plant on land a hundred and fifty miles from the load center and using a closed-cycle cooling system.

By the end of the century, the rising demand for energy in all forms will be exerting great pressure on the supply of fossil fuels, and perhaps on nuclear fuels. This pressure will lead to the use of other sources of energy, and this will in turn affect the siting of power plants both directly and indirectly. If fusion power becomes available, there will be a whole new set of problems in siting them but the problems will be somewhat similar to those of siting nuclear power plants, because the fusion plants will be large electrical generating plants which need only small amounts of fuel.

Another source of power that may become important in some areas is geothermal energy. In this case the site for a power plant is pretty well fixed by the location at which the energy is available. The problems in this case are likely to be cooling and the disposal of the condensed steam. Usually, the source is tapped by withdrawing natural steam and water. Typically, this water is loaded with minerals from contact with hot volcanic rock and is a pollutant if indiscriminately dumped.

In the long run, unless something like nuclear fusion gives us essentially unlimited power, the cost of electric power will rise as fuels, both fossil and nuclear, become in shorter supply. It will then behoove us to conserve electric power (there are many who think we are already in that circumstance). Even with an unlimited supply we will begin to suffer local climatic changes because of the excess dissipated energy dumped into the atmosphere over urban areas. The "thermal dome" over cities is already a well recognized phenomenon. One way of limiting this thermal effect is by the use of solar energy, particularly for low-grade uses such as water and space heating. A proper balance between electric power and other forms of energy will ease the problem of power plant siting and allow the power companies to provide the electric power our society really needs.

In summary, the large densely populated areas which will exist along the east coast, the west coast, around the great lakes, and along the gulf coast after 1990 will probably be supplied power by a combination of fossil power plants with closed-cycle cooling located inland and nuclear power plants located in deep water offshore. As the processing of fossil fuels into light clean-burning hydrocarbons comes into widespread use the fossil-fuel burning plants may also move offshore. In the long run it will be necessary to supplement the generation of electric power from fossil fuels and nuclear fission by other means of generation, e.g. by using geothermal energy or nuclear fusion. It will also be necessary to supplement the use of electric power by other kinds of power, particularly solar power for low grade uses such as water and space heating.

8

ABOUT THE AUTHORS

8. *About the Authors*

PETER BORRELLI, Eastern Conservation Representative of the Sierra Club, has worked with a variety of public interest groups, scientists and lawmakers in challenging existing power plant siting policies. Before joining the Sierra Club staff in 1968 he was a correspondent for *Time Magazine* in Washington and New York.

MAHLON EASTERLING is a Senior Member of the Technical Staff at the Caltech Jet Propulsion Laboratory. His work has been in telecommunications, developing ranging systems, planetary radars and telemetry systems. He has published a number of papers in his field, is the co-author of one book and contributor to two others, and holds four United States patents. At present he is spending most of his time as a senior staff member at the EQL on leave from Jet Propulsion Laboratory.

BURTON H. KLEIN is a professor of economics at Caltech. He was formerly head of the Economics Department at The RAND Corporation and a consultant to numerous Federal government agencies. He served as a staff member on the President's Council of Economic Advisers and as a Special Assistant to the Secretary of Defense. He is the author of a well-known book "Germany's Economic Preparations for War"; two new books are awaiting publication. Dr. Klein is a senior member of the EQL staff.

LESTER LEES is a professor of aeronautics and environmental engineering at Caltech. He is the author of numerous papers on problems of high speed flight, especially entry of missiles and spacecraft into planetary atmospheres He has also worked on the identification of such objects by means of their wake signatures. He is a consultant to the aerospace industry and to several government agencies. In the last two years his main interests have shifted to large-scale environmental problems, and he is now Director of the EQL.

GUY PAUKER is a Senior Staff Member, Social Science Department, the RAND Corporation. He is the author of numerous papers on Southeast Asia, especially Indonesia, and was formerly chairman, Center for Southeast Asian Studies, University of California at Berkeley. Recently he has become intrigued by the political and social problems posed by environmental constraints and changing human values, and he is now spending a portion of his time with the EQL.

ROBERT H. POPPE is Staff Assistant–Environmental Affairs, Northern States Power Company, Minneapolis, Minnesota. He is a biologist by training and has worked in the fields of environmental education and educational research before coming with NSP. These work experiences included university teaching, curriculum development and park planning for educational purposes. In addition he has conducted academic research in aquatic ecology. Mr. Poppe has been with NSP for approximately two years, and his major areas of responsibility with the company and its Department of Environmental Affairs is the organization and administration of NSP's Citizens Advisory Task Force and other company activities involving the general public in the company's environmental planning activities. In addition to this function, Mr. Poppe coordinates environmental evaluations of new construction projects and coordinates the technological aspects of the department's activities.

EQL, the Environmental Quality Laboratory, is an informally organized group of engineers, natural scientists, and social scientists who are dealing with broad, strategic problems of environmental control. Their "laboratory" is actually the world in which these problems must be solved. They interact with decision-makers in industry, government, and the ecology movement. Organized at the California Institute of Technology in 1970 in cooperation with the Jet Propulsion Laboratory and The RAND Corporation, EQL is supported by the National Science Foundation and private gifts.

Appendix A

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U.S. ACTS TO PREVENT LAKE MICHIGAN HEATING

by
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CHICAGO—The Nixon Administration's Environmental Protection Agency took its strongest stand to date against heat pollution in the nation's waters by declaring that all new power plants around Lake Michigan should have closed-cycle cooling systems using cooling towers or other devices to prevent the discharge of heated water into the lake.

If the proposal is adopted by the four-state enforcement conference here, federal authorities have said they will try to apply equally stringent standards to the other four Great Lakes.

Federal officials also regard the statement as setting a precedent for nuclear power plants scheduled for construction along the Pacific and Atlantic coasts and along inland lakes and streams.

Companies Critical

Power companies have been critical of proposals to build closed-cycle systems because of the expense added by construction of the massive cooling towers. In large bodies of water such as Lake Michigan, companies have also argued that there is no evidence that thermal discharges adversely affect marine life.

"In the face of such unknowns", stated Environmental Protection Agency Administrator William D. Ruckelshaus, "we must choose the course of caution. For far too long precautions against environmental damage have awaited a full understanding of the threat.

"The march of progress has aggravated environmental damage while proposed safeguards were under consideration or studies were being performed. In the case of Lake Michigan, we cannot afford further delay." Ruckelhaus, who is not attending the two-day conference, made the Administration statement by letter.

The announcement of the new proposed federal standards drew the praise of conservationists present at the conference but drew criticism from some of the representatives of the states, including serious questions from the Illinois conferee. Two federal commissions, the Federal Power Commission and the Atomic Energy Commission, also expressed reservations about parts of the plan.

Wisconsin Gov. Patrick Lucey, a Democrat, however, wired the conference that he supported the Administration plan to require cooling towers for nuclear plants.

If the representatives of the four states adjoining Michigan (Illinois, Wisconsin, Indiana, and Michigan) refuse to agree with the new standards, Francis T. Mayo, Midwest water quality coordinator for the EPA, said the agency was prepared to employ administrative processes to achieve the standards. Such processes could include calling a special standard-setting hearing or taking the states to court.