BALANCING ENERGY AND THE ENVIRONMENT: THE CASE OF GEOTHERMAL DEVELOPMENT

PREPARED FOR THE DEPARTMENT OF ENERGY

PHYLLIS L. ELLICKSON, WITH SAUNDRA BREWER
AND KATHLEEN KNIGHT

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PREFACE

This report provides the results of part of a Rand study on the federal role in resolving environmental issues arising out of the implementation of energy projects. The projects discussed are two geothermal programs in California: the steam resource development at The Geysers (Lake and Sonoma counties) in northern California, and the wet brine development in the Imperial Valley in southern California.

The research reported here was undertaken in 1976-1977 as part of a policy research program sponsored by the Energy Research and Development Administration (now incorporated in the Department of Energy).

SUMMARY

Since the passage of the National Environmental Policy Act of 1969 and the oil crisis of 1973-1974, decisionmakers at all levels of government have become increasingly concerned about balancing energy and environmental goals. This study asks what the Department of Energy's (DOE) role might be in the resolution of environmental issues that arise *during the implementation of energy projects*. Using geothermal development in California as a case study, it addresses the following questions:

- o What issues have arisen as disputes? Who are the principal actors involved? And through what processes have environmental issues been raised and resolved?
- o Under what circumstances can DOE involvement in environmental issues lead to more satisfactory outcomes for the parties involved?
- o What options are available to DOE in resolving environmental issues and how can DOE determine which option is optimal?
- o How can DOE develop effective working relationships with governmental and private groups whose interests are affected by the siting and operation of energy projects?

We define *implementation* as beginning with efforts to establish an energy facility in a particular site or area. Two geothermal programs in California meet that description: the steam resource development at The Geysers (Lake and Sonoma Counties) in northern California and the wet brine development at the Imperial Valley in southern California. The analysis focuses on environmental issues associated with implementation because that is when the most serious environmental objections often arise and when many federal programs encounter difficulty. Hence the environmental concerns expressed during implementation serve as a test of the relevance and feasibility of national energy policies.

In asking how the federal government might contribute to the resolution of environmental conflicts, we have sought to understand the *processes* by which energy and environmental tradeoffs are actually made and to use that understanding to suggest options for federal action.

PRINCIPAL FINDINGS

In California, environmental opposition to geothermal development has generally arisen out of local concerns. Local, as opposed to state or national, environmental groups have expressed most of the concern about environmental problems to date. The regulatory agencies that have power to modify a proposed well or plant and that have actually intervened on environmental grounds are also predominantly local.

The result is that a small number of opponents can strongly affect the outcome in a county. And the degree of their opposition is not related to the severity of geothermal impacts as compared with the impacts of other sources. For example, the residents of Lake County, California, do not compare the environmental impact of geothermal with that of coal or of oil shale; rather they compare its impact with the effect of no development. Hence balancing energy and environment goals at the level of national policy is no guarantee against opposition when that policy is implemented in a specific location.

Environmental conflicts over geothermal development in California are not usually rooted in uncompromising opposition to any and all development. Instead, the opposition has called for the mitigation of specific impacts such as air pollution and the degradation of valued scenic and recreational amenities. Nevertheless, environmentalists have found it useful to expand the conflict to the courts as a way of increasing the costs of indifference to their concerns. This strategy has, in turn, enhanced the incentives for bargaining and accommodation among developers, citizen groups, and local officials. The result is a more realistic bargaining climate for resolving conflicts between environmental and energy goals.

The localized nature of conflicts over geothermal development in California is advantageous in that the conflicts are generally played

out in the most relevant area--that geographical area most likely to be affected (positively and negatively) by development. But the regulatory process is highly complex and difficult for developers, environmentalists, and public officials alike to grasp. Consequently, efforts to resolve conflicts face two major constraints:

1. The need to understand the local context in order to identify the issues and parties involved, to ascertain the options for bargaining, and to find ways of implementing new arrangements within the existing institutional structure.
2. The need to adapt to changing conditions and practices over time.

For the federal government to understand the local context and adapt to change, it must have a local interface capability--at least a group of personnel who can provide headquarters with reliable inputs about the relevant local and state actors, regulations, and interests likely to be affected by a specific program; at most a locally based staff with enough authority to make binding commitments and work cooperatively and flexibly with the relevant parties in project implementation. Federal agencies lacking this capacity will be severely hindered in any efforts to balance environmental and energy goals.

We are not suggesting that the federal government should decentralize all decisionmaking to the local level. And we recognize that local actions to protect the environment may work against national priorities to increase energy supplies. Nevertheless, environmental concerns have become increasingly salient throughout the nation, as have the options for addressing them provided by recent legislation, court rulings, and regulatory practice. Even developers of a relatively benign resource like geothermal have faced fierce opposition followed by subsequent scheduling delays and rising costs. In the absence of a greater national consensus on the nature of the energy problem and its solution, federal preemption of state and local decisionmaking seems unrealistic.

Hence we think it is more fruitful for the federal government to

work *with* local citizens and governments, and our consideration of the options for federal involvement reflects this approach: each option presupposes a spirit of cooperation or bargaining rather than one of federal dominance.

OPTIONS FOR INVOLVEMENT

Three of the five options shown below--facilitating cooperative endeavors, conducting studies, and mediating disputes--are forms of *direct*, as opposed to indirect, involvement of federal personnel. Undertaking any of them involves considerably more organizational flexibility, political acumen, and understanding of the local context than does the providing of information or funds.

PASSIVE							ACTIVE
	No	Disseminating	Providing	Facilitating	Conducting	Mediating	
	role	information	funds	cooperative	studies	disputes	
				endeavors			

Hence a decision in favor of direct involvement requires careful consideration of whether it will facilitate a successful resolution of environmental questions. Our analysis of geothermal development suggests that direct federal involvement is unlikely to facilitate such a resolution in the absence of local demand for federal action. Moreover, when a federal agency is directly involved in environmental issues associated with implementation, the primary variable affecting successful outcomes is the strength of the interface between the federal agency and the local and state participants. While the most extreme form of direct federal involvement--preemption of local or state authority--is unrealistic, streamlining the regulatory process within and across localities is often possible. The federal government can play a role in this process by providing monetary or technical support to cooperative intergovernmental groups.

CRITERIA FOR INVOLVEMENT

The federal government's decision to become involved in resolving environmental issues is often constrained by other factors, such as

a prior commitment to commercialization, which have little to do with the appropriateness of a federal role in environmental issues. To the extent that choices can be made, however, we suggest that the following criteria are important.

1. *What are the attitudes of the key local parties toward direct federal involvement?*

When a federal agency's presence and assistance are not desired, it is highly unlikely that it can be useful in providing funds, mediating disputes, conducting studies, or facilitating cooperative endeavors.

2. *To what extent are the financial resources and expertise of the local parties adequate to perform the planning and analysis necessary for dealing with environmental questions?*

If local resources and expertise are generally viewed as adequate, no federal involvement in funding studies is indicated. If resources are inadequate but expertise is available, the federal government may consider funding the necessary studies through local parties. Local people often prefer this route because it gives them control over the money and increases the chance that the money will be used in ways they feel are most important. Only when local parties have neither the resources nor the ability to obtain the requisite expertise should the federal government step in to conduct a study or project.

3. *How well developed are the existing institutions and regulatory processes for dealing with environmental issues?*

If existing processes for allowing access and settling disputes are functioning well, there is probably little that active federal involvement in mediating conflicts can accomplish. Mediating disputes is very difficult, especially when a federal agency may be perceived (or may come to be perceived) as having vested interests in the outcome.

4. *How would federal intervention affect the complexity of the process by which environmental issues are resolved?*

The addition of a federal agency to a local process can bring with it a host of legal and administrative requirements (such as additional impact statements, new accounting procedures, hiring guidelines, and reporting requirements) that can materially offset any advantages the

agency may offer. The effect may be to reduce the flexibility of local parties, by an amount greater than the value of the federal agency's contribution.

5. *Last, but surely not least, does the agency have the organizational capacity to intervene in the manner contemplated?*

To mediate disputes effectively or to conduct on-site projects and studies requires a substantial political as well as technical presence that is sometimes unavailable to federal agencies. Neither regional laboratories nor headquarters staff can substitute for a local office that can deal effectively with state and local government agencies and private organizations within a region.

ORGANIZATIONAL IMPLICATIONS

Many of the criteria suggested above require a knowledge of the local context that is not always available to federal agencies. Even when the federal government is only indirectly involved in site-specific project implementation, it still requires some "on the ground" contact.

Field offices are the logical agents for developing local contacts, experience, and expertise. But in order to perform this role effectively, field offices need to be appropriately staffed, granted sufficient authority to function as more independent arms of the federal agency, and strategically located. The creation of a Department of Energy offers the opportunity to initiate a thorough reevaluation of field office location and capabilities.

As we have emphasized, if the federal government takes an *active* role in project implementation, it must develop a strong local interface. Doing so requires a local presence: a group of project managers and staff who have frequent contacts with local actors and are able to identify and respond to the constraints of the project's local setting.

It is also important that projects not be undertaken largely for the purpose of enhancing or maintaining the federal agency's own organizational structure. It is difficult enough to develop constructive relationships with local officials even when there is a considerable effort to accommodate local concerns and priorities. ERDA's

initial negotiations for environmental planning studies in the four-county Geysers region were perceived by county officials as biased by an organizational motive to provide work for one of the laboratories. Even when the federal government's expertise is substantial, such a motive should not be the primary reason for project initiation.

The basic characteristics associated with successful projects are those that appear to make the Imperial Valley Environmental Project work:

- o Knowledge of local politics, regulatory processes, and issues.
- o Participation by local interests.
- o Promotion and support of the project at headquarters.
- o Clear lines of communication.
- o Capacity to adapt to changing conditions.

Combined with local as opposed to federal initiative, the project characteristics noted above have been identified as key components of successful implementation throughout the federal government. While the data base is limited, the basic features of environmental conflict resolution identified here--dominance of local (as opposed to national) interests, regulatory and political variability across space and time, change in environmental tactics and concerns--appear typical of energy project implementation in the United States. These findings suggest that the conclusions of this study can be generalized beyond the immediate arena of geothermal development.

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Any errors are solely the responsibility of the authors.

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GLOSSARY

AIHL	Air and Industrial Hygiene Laboratory
APCD	Air Pollution Control District
ARB	Air Resources Board
BER	Biomedical and Environmental Research
CEQA	California Environmental Quality Act
CERCDC	California Energy Resources Conservation and Development Commission
CPUC	California Public Utilities Commission
DFG	Department of Fish and Game
DOE	Department of Energy
DOG	Division of Oil and Gas
DOI	Department of the Interior
DTO	Division of Technology Overview
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	Environmental Policy Act
ERDA	Energy Research and Development Administration
GRIPS	Geothermal Resource Impact Planning Study
H ₂ S	hydrogen sulfide
ISC	Industrial Safety Code
IVEP	Imperial Valley Environmental Project
KGRA	Known Geothermal Resource Area
LCAPCD	Lake County Air Pollution Control District
LCEC	Lake County Energy Council
LLL	Lawrence Livermore Laboratory

LNG	liquefied natural gas
MEA	Master Environmental Assessment
ND	Negative Declaration
NEPA	National Environmental Policy Act
PG&E	Pacific Gas and Electric
PNWL	Pacific Northwest Laboratory
PUC	Public Utilities Commission
RWQCB	Regional Water Quality Control Board
SAN	ERDA's San Francisco Office
SDG&E	San Diego Gas and Electric
SLC	State Lands Commission
USGS	U.S. Geological Survey

I. INTRODUCTION

The goal of providing the nation with an ample supply of energy often sharply conflicts with the goal of environmental protection. The need to balance these conflicting goals was explicitly recognized by the Energy Research and Development Administration (now part of the Department of Energy) in its national energy plans.¹

This study examines one important facet of the process of balancing environmental and energy development goals: the resolution of environmental issues which arise during the course of energy project implementation. It focuses on environmental issues surrounding California's geothermal resources, in particular the steam resource at The Geysers Known Geothermal Resource Area (KGRA)² in northern California and the hot water resource in the Imperial Valley in southern California. A companion report integrates the findings of this study with our analysis of the development of oil shale in the Rocky Mountain Region.³ These two energy resources were chosen for study because they offer the possibility of studying environmental issues under different conditions of technological maturity, environmental uncertainty and conflict, and institutional complexity.

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¹Our research was conducted before the Department of Energy (DOE) absorbed ERDA. Since DOE's jurisdiction includes responsibility for ERDA's former activities and facilities, the findings reported here are equally relevant to the new department. Throughout the report, we refer to ERDA when discussing past agency activities and to DOE when discussing future options.

²Referred to throughout this report as The Geysers. Although sections of four counties (Lake, Sonoma, Mendocino, and Napa) are included in this KGRA, the present study focuses on the two counties where development is most active--Sonoma and Lake.

Areas are designated as KGRAs by measuring temperature gradients within the thermal anomalies. Resources with temperatures above 150°C are capable of generating electricity; those below are confined to process and space heating uses.

³E. Merrow and P. Ellickson, *Resolving Environmental Issues in Energy Development: Roles for DOE and Its Field Offices*, The Rand Corporation, R-2335-DOE, forthcoming.

We define energy project implementation as beginning at the point when site or area specific planning for a project commences. Such projects may begin at any stage in the development of an energy technology or resource beyond the laboratory. Thus projects that fall within the scope of this study range from the Imperial Valley Environmental Project (IVEP), which involves environmental research for geothermal development, to projects involving "mature" technologies such as hot steam geothermal reservoirs.

In this section we discuss why we chose to focus on the resolution of environmental issues as they arise during implementation. We also delineate the principal questions addressed in the study, briefly explain our research procedures and the manner in which environmental issues, processes, and outcomes are examined, and define the options for involvement that arise during the implementation of energy projects.

STUDY GOALS

The opportunity to make tradeoffs between energy and environmental goals arises at a number of levels that are relevant to the Department of Energy:

1. At the level of national energy policy, as in the choice to encourage the use of a particular energy resource such as coal, or to place greater emphasis on conservation as opposed to supply expansion.
2. At the level of research and development, as in a decision to emphasize the development of technologies that are environmentally superior to those they would replace (such as the fluidized bed for coal combustion).
3. At the level of project implementation.

We chose to focus our research on the resolution of environmental concerns during implementation because that is when the most serious environmental objections often arise and when many federal programs encounter difficulty. Several studies have shown that when federal projects fail to achieve their goals, the project has not been adapted to

the concerns of local¹ people who must at least accept the project's presence and, in some cases, implement it.²

Implementation problems have been important to ERDA and will be even more so as the new Department of Energy begins to carry out its energy supply and conservation technology policies. Environmental concerns have affected oil shale and geothermal resource development programs and are likely to affect implementation of the Administration's program for increased utilization of coal.

Finally, implementation issues clearly affect the realism of any national policy. Policies that attempt to balance environmental and energy concerns at the national level will falter unless the resulting projects can be successfully implemented at the local level. The light water nuclear reactor experience has dramatized the extent to which environmental opposition can spur changes in federal standards, procedures, and R&D, as well as changes in plant design, siting, and operations.³ In sum, the environmental concerns expressed during implementation can serve as a test of relevance for both national planning and the R&D process.

In asking how the federal government might contribute to the resolution of environmental conflicts, we have sought to understand the processes by which energy and environmental tradeoffs are actually made and to use that understanding to suggest options for federal action. We view environmental quality as a good which is inadequately allocated by the market--largely because people do not own rights to clean air or water and hence cannot raise the costs of pollution by selling (or refusing to sell) rights to pollute. Hence, private firms have few

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¹In this report, the word "local" is construed broadly to mean those directly involved in or affected by project implementation and does not necessarily refer to local governments or to those who live near an energy project.

²P. Berman, M. McLaughlin, et al., *Federal Programs Supporting Educational Change*, The Rand Corporation, R-1589-HEW, 7 volumes, 1974-1977; W. Baer, L. Johnson, and E. Merrow, *Analysis of Federally Funded Demonstration Projects*, The Rand Corporation, R-1926-DOC, 1976.

³See E. Rolph, *Regulation of Nuclear Power: The Case of the Light Water Reactor*, The Rand Corporation, R-2104-NSF, June 1977.

incentives to protect the environment, and tradeoffs between environmental quality and energy production have to be made in the political market--through the formal means of legislation, court action, and regulation, or the more informal means of pressure politics.

To understand the potential federal role in such tradeoffs, we have sought to clarify how this political market works--in particular to *understand the nature of the processes through which energy and environmental tradeoffs are resolved*. Hence we have sought answers to the following questions about the development of geothermal resources in California:

- o To what degree do environmental conflicts impede development of the resource? What environmental issues are associated with geothermal development? (Sections II and III)
- o What is the regulatory and political context within which environmental issues are resolved? (Section VI)
  - When have environmental issues arisen as disputes? Why?
  - Who are the principal public and private actors concerned with environmental issues? How has involvement occurred? Who has been left out or failed to participate, and with what effect?
  - Through what mechanisms (e.g., the courts, regulatory bodies, informal contacts) have environmental issues been raised? What are the outcomes of the resolution process?
- o What has been the nature of ERDA's involvement in resolving environmental issues associated with geothermal development in California? What can we learn from the agency's past experience? (Section V)

Our examination of the first two questions resulted in several findings about the sources of environmental opposition to geothermal development in California, the processes through which environmental issues are resolved, and the outcomes of those processes. These findings are detailed in Section VI. Combined with our assessment of ERDA's past experience, they provide the basis for our answers to the following questions (addressed in Section VII):

- o Under what circumstances can DOE involvement in environmental issues lead to more satisfactory outcomes for the parties involved?
- o How can DOE determine its appropriate role(s) in resolving environmental issues, such as providing information, funding or conducting studies, or mediating conflicts among interested parties?
- o How can DOE develop effective working relationships with state and local groups, both public and private, that are involved in the implementation of energy projects and the resolution of environmental issues?

RESEARCH PROCEDURES

To study how environmental issues are resolved during project implementation, we focused on acquiring detailed information about the issues, actors, strategies, and results of environmental conflicts over geothermal development. We interviewed many people concerned with the development of California's geothermal resources--including local, state, and federal officials, developers, and environmental or other private citizen groups who have expressed interest in geothermal projects.

This subsection discusses how we selected the cases for analysis and the criteria we employed for examining the outcomes of site-related environmental disputes.

Case Selection

Ideally, this study would examine a large number of geothermal projects in which ERDA had been involved. The sample is small, however, because ERDA was a new agency and had only recently become directly involved in geothermal project implementation. But for that very reason, it is all the more important to review those cases in which the agency has taken an active role. We chose to examine geothermal development in two areas of California--the Imperial Valley and The Geysers. These two cases offer a number of analytic advantages.

In the Imperial Valley, ERDA has conducted a major environmental baseline study (in association with the funding of a test facility) which provides an example of site-related project implementation. At

The Geysers, commercial development has been proceeding over a number of years, and ERDA has expressed considerable interest in becoming involved there in the resolution of environmental and related issues.

Associated with the development of these resources are technologies at different levels of development: the steam-dominated resource at The Geysers involves known technology in commercial use; the Imperial Valley project involves technology that has not been commercially employed in the United States. These situations open up the possibility of exploring the potential effects of the technological state-of-the-art on the extent to which environmental issues are perceived.

The cases chosen also differ in the extent to which environmental groups are present and concerned about development, and in the regulatory and political processes by which environmental issues are resolved. In the Imperial Valley, conflict over geothermal development is still nascent and the capacity of regulatory agencies to respond to environmental opposition has not been seriously challenged. At The Geysers, environmental issues have been raised in the regulatory and political arenas for over a decade.

Finally, we note that our examination of geothermal development in each area has emphasized projects that have triggered environmental opposition during the past fifteen years. Since most of the development at The Geysers and the Imperial Valley has taken place on private and state lands, our analysis largely ignores environmental issues associated with the actual leasing and development of federal lands. But the problems illuminated in this study are relevant to the federal government for the following reasons: (1) many federal projects (such as the two ERDA-sponsored efforts examined here) affect development on non-federal lands; and (2) the concerns of county and state officials, as well as those of private groups, have already impinged on the development of federal lands and will continue to do so in the future.

Examining Outcomes

Because we are comparing projects at very different stages of development, gauging the success of a project simply on the basis of the extent of environmental protection versus the extent of energy production would be inappropriate. Furthermore, implementation processes

often produce a *series* of outcomes rather than a single and final resolution. Hence, we focus on the processes surrounding environmental issues and the outcomes of those processes. Our major criterion for success is the extent to which the parties involved report that they are satisfied with both the fairness of the process and any resolutions achieved.

We have chosen this approach because it is becoming increasingly apparent that the most effective way to achieve energy development goals is through acknowledging and accommodating the concerns of all the interested parties. Such accommodation does not mean that each interest gets precisely what it wants; it does mean that the involved parties feel they have been included in the process and that their concerns have been seriously considered. When these conditions are not met, the resolution is usually so fragile that it quickly breaks down.¹

While focusing mainly on the subjective measure of satisfaction of the parties involved, we also look at the following objective measures: the extent to which outcomes have been achieved in either (a) reducing the uncertainties about what environmental impacts will be or (b) allowing energy development to proceed while accommodating environmental concerns. Where such resolutions have occurred, they are important outcomes in their own right, as well as ingredients in the satisfaction of the parties concerned with environmental questions. Our ability to isolate them is, however, constrained by the fact that our cases vary substantially in both stage of resource development and stage of conflict resolution.

Options for Involvement

Our analysis of environmental conflict resolution led to several findings about the nature of the actors, processes, and outcomes involved in making tradeoffs between energy and environmental goals. In assessing the implications of these findings for DOE's role in resolving environmental issues that arise *during the implementation of energy*

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¹The extreme case of federal preemption is an exception. However, in the absence of a greater national consensus on the energy problem and its solution, federal preemption is not a realistic option.

projects, we considered the six options for involvement shown in the following diagram:¹

Among the options listed above, *no role* is self-defining. *Disseminating information* involves making environmental data at DOE's disposal available to interested parties involved in site-related environmental questions. The relatively simple task of providing information must be distinguished from the task of data transfer associated with site-related projects *conducted by* DOE. We include data transfer in the *conducting studies* option defined below, since communicating project information and expertise to local decisionmakers is an integral part of undertaking site-related activities.²

Providing funds can involve funding environmental studies (assessments or planning studies *not* conducted by DOE), providing monetary support to local organizations concerned with resolving environmental issues (regulatory agencies, local governments, joint governmental

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¹There is an important role for DOE in (1) the development of technological processes (such as slant drilling or fluidized bed combustion) initially designed to alleviate environmental problems associated with energy development and (2) laboratory studies of the unanticipated effects of resource extraction and conversion (such as how various emissions may affect plant and animal life over the longer term). Since industry has little incentive to worry about environmental effects that have not yet been identified, this latter area is one in which government funds are unlikely to duplicate private efforts. However, neither of these laboratory R&D options falls within the scope of this study, for neither is closely tied to implementation, i.e., site or area specific activity for an energy project. Hence, we have not included them in the above discussion.

²The ERDA-sponsored education program of the Oak Ridge Associated Universities is one example of information dissemination. The data transfer function is illustrated by the Imperial Valley Environmental Project, a site-specific research effort designed to provide inputs to the development and planning decisions of local governments and industry. Effective data transfer from such projects is predicated upon considerable local involvement in project planning and implementation; effective information dissemination does not depend on prior involvement of the users.

bodies, etc.), or making transfer payments to communities that have undue environmental damage. *Facilitating cooperative endeavors* can range from helping to get an environmental project off the ground (putting together the interested parties and locating sources of funds and expertise) to providing consultants to intergovernmental bodies or promoting cooperation and coordination among the many public and private entities actively involved in energy development and environmental protection.¹ *Conducting studies* includes actually undertaking environmental or planning analysis in conjunction with site-specific resource development (pilots, demonstrations, or private commercial enterprises). Finally, *mediating disputes* would include DOE's offer of its "good offices" in situations where DOE itself is not an interested party.

As one moves from left to right along the continuum, the need for a local interface capacity increases; the tax on ERDA's resources and organizational capacity grows; and the political component of ERDA's role becomes more important (in the sense that the need for coordinating, facilitating, and persuading becomes more critical). Hence our recommendations about which options are appropriate are inextricably linked with our assessment of ERDA's organizational and political resources.

ORGANIZATION OF THE REPORT

The remainder of this report is organized as follows. Sections II and III provide a background discussion of the technical, economic, and environmental issues surrounding the development of geothermal resources in California. In Section IV we discuss the regulatory context within which geothermal resources are developed, with particular emphasis on the actors, issues, and processes involved in environmental conflicts at The Geysers and the Imperial Valley.

Section V examines ERDA's involvement in the Imperial Valley Environmental Project and touches briefly on ERDA's negotiations for a

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¹In many areas, cooperation with the Environmental Protection Agency (EPA) is an important option for DOE. However, to date EPA has been only tangentially involved in the cases we have analyzed; hence we have not examined the relationship between the two agencies.

similar project in The Geysers region. In Section VI, we present our general conclusions about the sources of environmental opposition to geothermal development, the processes through which issues are resolving, and the outcomes of those processes. These findings then lead to implications for the roles that the new Department of Energy might play in the resolution of environmental questions arising during implementation (Section VII).

II. TECHNICAL AND ECONOMIC ISSUES IN GEOHERMAL DEVELOPMENT

This study focuses on vapor-dominated and liquid-dominated hydrothermal systems, which together account for all the electricity currently produced from the world's geothermal reserves. The largest geothermal power plant in the world is located at the dry steam reservoir in The Geysers, California. However, electricity has not been produced commercially at any of the liquid-dominated reservoirs in the United States.

Geothermal energy is derived from the natural heat of the earth. The earth's temperature increases inward toward the core, ranging from 200°C to 1000°C at the base of the continental crust. While most of the earth's heat is too deeply buried to be utilized by man, the outer 10 kilometers of the earth's crust have been estimated to contain more than 2000 times the energy represented by the world's total coal resources (White, 1965). Most of this energy is too diffuse to be recovered economically, but where it is concentrated into restricted volumes at shallow depths (10 kilometers or less), economic recovery is a possibility.

Geothermal energy is stored both in hot rock and in water and steam which fills rock pores and fractures.¹ The resource is usually categorized into five classes, according to the nature of the energy medium:

1. *Dry steam reservoirs* (or vapor-dominated geothermal systems), which produce superheated steam (with minor amounts of gases such as hydrogen sulfide, ammonia, and carbon dioxide) but little or no water.
2. *Wet-steam reservoirs* (or liquid-dominated convective thermal systems), which produce superheated fluids containing minerals

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¹Concentrated geothermal energy emanates from large bodies of hot molten rock that have flowed upward into the earth's crust. These hot bodies of magma heat the adjacent rocks in the crust near the surface, which in turn heat the water contained in any fissures or pores.

and gases in solution (predominantly chlorides, bicarbonates, sulfates, borates, and silica compounds). The geologic structures of vapor-dominated and water-dominated reservoirs are essentially the same. The two systems differ basically in the amount of fluid present in the deposit.

3. *Geopressured deposits*, which contain heated water trapped in impermeable clay and shale beds. Geopressured waters have medium temperatures and are characterized by a low salinity. They are commonly saturated with up to one cubic meter of removable natural gas per barrel of water.
4. *Hot dry rock deposits*, where magma (molten rock) has intruded close enough to the surface to heat overlying rock to high temperatures. No water is present.
5. *Magma systems*, where the heat is contained in liquid or near-liquid rock at temperatures ranging from 600°C to 1500°C.

As background for our discussion of the environmental issues surrounding geothermal development in California, this section briefly describes the technical and economic status of electricity production from California's hydrothermal systems. It focuses on two of the state's major reservoirs, The Geysers dry steam system located in Northern California and the hot brine system in Southern California's Imperial Valley.¹ Appendixes A and B provide additional details for readers interested in a more complete description of each area and its geothermal history.

TECHNICAL AND ECONOMIC UNCERTAINTIES AT THE GEYSERS

Uncertainty about the technical or economic feasibility of producing electricity from the vapor-dominated resource at The Geysers is minimal. The technological problems of producing power from dry steam have been resolved; similarly the economics is both understood and competitive with other electricity sources.

Operating experience with plants producing electricity from the steam resource has been accumulating since 1960. Pacific Gas & Electric

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¹Figure 1 shows the geographical location of each resource.

Fig. 1--Location of Imperial, Lake, Mendocino, Napa, and Sonoma counties

(PG&E), which now has eleven plants producing 502 megawatts of electricity (Mwe), plans to add an additional 406 Mwe by 1979. All of the existing plants are located in Sonoma County. One plant is under construction in adjacent Lake County, and at least nine companies have undertaken drilling or applied for permits there.

To convert a vapor-dominated resource to electricity is relatively simple. Conventional oil field drilling methods are used to tap the reservoir, with compressed air substituting for drilling mud after the initial drilling stages. Particulate matter is removed from the well-head steam by simple filters, and the steam is routed through insulated pipes to the plant, where it passes through a relatively inexpensive turbine generator to generate electrical power.

The steam is then routed to a direct contact condenser where cooling water mixes with the steam and condenses it. The liquid coolant and condensate are pumped to the cooling tower, where most of the condensed water is evaporated. About 20 percent is not evaporated; for several years this mix of cooling water and condensate has been successfully injected back into the reservoir.

The major technical problems faced in the past stemmed from impurities in the steam which corroded plant equipment. Use of separators and special alloys has alleviated these difficulties, and improvements continue to be made.

The major remaining technological problem is how best to reduce hydrogen sulfide (H_2S) emissions. Two abatement methods are available today--the iron catalyst and the Stretford scrubber. The first reduces emissions from the cooling tower by about 40 to 70 percent¹ but also corrodes the equipment, causes well plugging, and creates solid waste discharge problems. The Stretford scrubber is expected to reduce emissions from the gas injectors by approximately 98 percent but is uneconomical for existing units with direct contact condensers (Tolmasoff, 1976).

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¹While tests in 1974 revealed an overall H_2S abatement of 92 to 94 percent (Tolmasoff, 1976), actual use of the iron catalyst has proved to be only 40 to 70 percent effective (personal communication with Northern Sonoma Air Pollution Control District (NSAPCD) officer, March 1978).

Five PG&E operating units (Units 3, 4, 5, 6, and 11) have been retrofitted to use the iron catalyst method, and several planned units have been designed to use the Stretford scrubbers.¹ However, a third option that applies a copper sulfate solution before the steam enters the turbines is now being tested by PG&E (under a contract with ERDA) and may prove to be technologically and economically superior.

Costs²

The average cost of power generated at The Geysers from 1961 through 1974 was 5.6 mills per net kilowatt hour (kwh) generated (Matthew, 1975).³ This compares favorably with the cost of electricity generated from other fuels during the period.

The cost of power production for units scheduled to come on line in the late 1970s will be substantially higher due to increases in construction, manpower, and machinery costs, the requirements for installing new abatement methods, and potential regulatory delays.

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¹PG&E originally agreed to retrofit Units 3, 4, 5, and 6 with the iron catalyst systems by July 1977 as a condition for the permitting of Units 12, 14, and 15. Because of the potential for well plugging and damage to the reservoir, they did not meet the schedule for Units 5 and 6. An interim conditional agreement allowed them to manually induce the iron catalyst into Units 5 and 6 when a hydrogen sulfide episode was predicted. As of January 1978, PG&E had installed continuous abatement equipment on Units 3, 4, 5, 6, and 11. PG&E is still behind on the original schedule for retrofitting Units 7 through 10 but, as of this writing, hearings on continuing the variance are under way (personal communication with NSAPCD officers, July 21, 1977, and March 20, 1978).

²This discussion is based on a detailed examination of cost projections from the following sources: Armstead (1973), California Public Utilities Commission (1975), Edmunds (1976), Grieder (1976a), Krumland (1976), Ramachandran (1977a and b), and Worthington (1975). For a breakdown of these estimates, see Appendix C.

³The cost of geothermal power can conveniently be separated into exploratory costs, costs of land acquisition, costs of production and disposal wells, costs of the surface fluid gathering and disposal system, plant costs, and the cost of money. At The Geysers, the steam developer incurs the exploration costs, the costs of land acquisition, the costs of production and disposal wells, and the costs of steam transmission facilities. The utility incurs the costs of the generating unit and electric transmission facilities and purchases energy from the developer.

As Table 1 indicates, however, power generated from new geothermal steam plants at The Geysers will still be competitive with power generated from new nuclear or coal plants. The cost of electricity generation at units scheduled to come on line in 1978 and 1979 and later is in the range of 20-25 mills/kwh (Krumland, 1976). Estimated average plant capital costs for new Units 12-15 are \$222/kw.¹ Capital costs are projected to range between \$250 and \$280/kw for later units (Krumland, 1976). These figures are well below the estimated power and capital costs for nuclear and coal facilities coming on line in the mid-1980s, indicating that investment in The Geysers steam resource will continue to be profitable.

Table 1
COST PROJECTIONS OF FUTURE POWER GENERATION FACILITIES
FOR THE WESTERN UNITED STATES

Energy Source	Mw	Cost of Power (mills/kwh)	Capital Cost (1976 \$/kw)
Geothermal ^a			
Steam	50-200	20-25	250-280
Hot water (150-200°C)	50-200	35-72	550-800
Nuclear (LWR) ^b	700-1300	29-30	720-830
Coal fired ^c	500-1200	29-33	570-600

^aDerived from a comparative review of the geothermal cost literature adjusted to constant dollars (see Appendix C). Includes projections for reservoirs most likely to be developed in the next ten years and excludes outdated estimates or those based on an incomplete data base.

^bBased on Cazalet (1976), Barrager and Quinn (1977), and TRW (1977).

^cBased on Cazalet (1976), Barrager and Quinn (1977), and TRW (1977). Includes cost of flue gas desulfurization since all new facilities must be so equipped in accordance with the EPA ruling.

¹Measured in 1976 dollars. Delays in the installation timetable may increase the estimated capital costs.

However, one must also recognize that The Geysers is a unique resource--the only proven dry steam reservoir in the United States. Development of the field has been singularly successful because the steam is of high quality, the reservoirs are shallow and could be developed at relatively low cost, and the technology for steam utilization was available at the time the development began. Unless new systems are discovered with similar features, the economics of The Geysers cannot be used as the criterion for evaluating other vapor-dominated resources. Certainly, economic experience at The Geysers cannot be generalized to water-dominated resources such as those underlying the Imperial Valley.

TECHNICAL AND ECONOMIC UNCERTAINTIES IN THE IMPERIAL VALLEY

In the United States, the technical and economic feasibility of producing electricity from hot brine resources is considerably less certain than that for vapor-dominated systems. No power plants using the hot brine resource have yet been built in this country.¹ Technical and economic uncertainties about the commercial viability of electricity production underlie this lack of development.

Technological Issues

Technical uncertainties affect the development of water-dominated geothermal systems from the initial stage of resource location through energy conversion. Resource assessment is still quite primitive--in fact, the only way to confirm whether or not the resource actually exists in a particular location is to drill for it.² However, drilling

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¹Power plants using the hot brine resource have been built in several other countries, including Mexico, New Zealand, Japan, and the USSR. These plants have all been constructed with some form of government subsidy.

²Estimates of the total U.S. geothermal resource potential differ by several orders of magnitude. For example, Dr. Joseph Barnea of the United Nations asserts that the 1975 estimates of geothermal resources from the United States Geological Survey (USGS) "appear to be 10 to 15 times higher than the estimates given by Dr. White (of USGS) in 1973" (*Geothermal Energy Magazine*, December 1975). Such conflicting estimates abound in the literature. While one can explain the variation by closely analyzing differences in definition and assumption, the practical point is that the gap occurs because the data are

for geothermal deposits is more expensive and more difficult than drilling for oil--costs for one exploratory well may range between \$400,000 and \$750,000. Even when the resource is found, there is considerable uncertainty about the size and longevity of the field--no one knows how large the fields are in the Imperial Valley nor how quickly they may be depleted.

Considerable uncertainty also surrounds the technology required to produce electricity from the geothermal brines found in the Imperial Valley. The fluids found at the Salton Sea, for example, are considerably more saline than those found in either Mexico or New Zealand where electricity is already produced from hot water reservoirs.¹ The corrosive nature of the brines means that new alloys, vessels, and procedures must be found to cope with problems of mineral deposits and, especially, of silica coating on the pipes and mechanical equipment.

It also means that the waste brine cannot be allowed to flow into fresh water streams as has been done in Mexico and New Zealand. While considerable work has been done on developing highly saline brine-resistant equipment and scrubbing and reinjection procedures, none of these methods or materials have been tested in a full size power plant. At present, we just do not know if they will work in a plant producing 50 megawatts or more.

Because of the varying temperature and salinity of hot water resources in the Imperial Valley, at least three different basic plant designs are being considered by utilities: flashed steam, binary fluid (or binary flow), and a hybrid combination of the two.²

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inadequate. As USGS itself states, "more precise estimates will require detailed investigations of the areas tabulated" and must include "extensive drilling, reservoir evaluations and research" (USGS Circular 726, 1975).

¹Salinity levels of 260,000 ppm have been measured near the Salton Sea as opposed to 13,000 to 25,000 ppm at Cerro Prieto, Mexico, and 35,000 ppm for ocean water.

²A fourth option, the total flow design, is being developed at Lawrence Livermore Laboratory. This system expands on the two-phase mixture of produced fluid through a converging-diverging type nozzle. The kinetic energy then drives a modified impulse turbine coupled to a generator. This approach eliminates the need for heat exchangers

The *flashed steam* option, which is the simplest and least expensive, uses conventional technology to flash the brines to a two-phase vapor-liquid flow. After the steam vapor is separated from the brines, it is expanded through conventional steam turbines connected to electric generators. Although currently used in several other countries, this option may be impractical for the highly saline fluids found in the Imperial Valley. Solid deposits on the turbine blades and in the liquid flow lines are a major obstacle to efficient utilization of this system. Moreover, flashed steam plants also tend to be unattractive for medium temperature reservoirs because steam yields from such fluids are very low and supply well costs may be too expensive compared with the binary system.

In *binary flow* designs, the geothermal brines are passed through a series of heat exchangers, and the thermal energy is transferred to a working fluid (e.g., isobutane, Freon, propane), which is vaporized through this heat transfer, superheated and expanded, and then passed through a turbine to produce electricity. The turbine cycle is closed, with the working fluid continuously circulating between the turbine and condenser materials. After passing through the heat exchangers, the brines are either reinjected or disposed of on the surface, as in the flash steam method.

When compared with flash steam technology, the binary flow technology has several attractive features. It reduces maintenance and scaling problems because corrosive brines do not come in contact with the turbines and other working loop components. Turbine efficiency is not affected by noncondensable gases. The system can be tailored to the temperature of the geothermal fluid, capturing a greater percentage of the heat value of the brines--a particular advantage for lower temperature reservoirs.

Disadvantages of the binary flow design include a higher capital investment, inadequate turbine development, and corrosion of the heat

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or flashing steam systems and is theoretically the most efficient design option. However, total flow systems are as yet unproven designs, while steam turbines and binary fluid heat converters are well known and tested technologies. Whether theoretical efficiencies can be achieved in practice--and achieved at reasonable costs--has yet to be demonstrated.

exchanger tubes. Capital costs are greater because the system requires larger heat transfer surface areas to extract thermal energy from the geothermal fluids. Turbines that can handle these organic working fluids in 50 to 100 Mwe plants do not exist (Krumland, 1977). And finally, highly saline brines corrode the heat exchanger tubes when they are cooled in direct contact with heat exchanger surfaces.

A process adapted for highly saline fluids combines flashing brines to steam with the subsequent steam heating of a working fluid in a binary flow system. This process, currently being tested by San Diego Gas & Electric, prevents the fouling of heat exchanger tubes which occurs in the simple binary cycle. But it shares the binary system's other disadvantages--higher capital costs and inadequate turbine development.

Costs

For several reasons, the cost of utilizing liquid-dominated systems for power generation is higher than for dry steam systems. In comparison with steam, greater volumes of hot brines are required to generate equivalent amounts of power. Hence more wells are required and a larger quantity of cooled fluid must be reinjected. Evaluation testing of the resource also raises costs. Because the quality of the resource is lower and thus larger quantities of briny liquids must be handled, the generating plant is more complex. Systems using resources below 400°F are very expensive; more than twice as many wells are required to supply a plant at 310°F than at 410°F (Grieder, 1976a).

Estimating the cost of producing power from liquid-dominated systems in the Imperial Valley is complicated by the degree to which the resource varies in temperature and mineral content as well as geological conditions. The figures presented below were compiled from the recent literature for hot water systems.¹ Because of the varying nature of each author's assumptions and the uncertain economics of the energy conversion processes currently under consideration (flashed steam,

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¹Bechtel (1976), Bloomster and Knutsen (1975), Edmunds (1976), Goldsmith (1976), Grieder (1976a), Hankin (1976), Holt/Procon (1976), Dart et al. (1975), Larson (1977), and Ramachandran (1977a and b). See Appendix C for a breakdown of their estimates.

binary-cycle, and hybrid), the estimates vary--even for a given technology. Hence they should be viewed as tentative and subject to change. But they do allow us to make a rough judgment about the competitiveness of electricity from production brines in the Valley.

Estimated plant costs appear to be in the \$550 to \$800/kw range. Under nominal to optimistic assumptions, costs of power are projected to be in the 35 mills/kwh range. Under more pessimistic assumptions, they could be as high as 72 mills/kwh, much higher than for vapor-dominated systems. Hence, power production from geothermal brines utilizing flash and binary technologies appears somewhat less competitive than power generated from nuclear energy or fossil fuels. However, the small size of geothermal plants gives them an advantage in areas where large units are either not needed or difficult to finance.

In the Imperial Valley, whether the resource will become commercially viable is still a moot point. The uncertainty in current cost estimates, technology development, availability of financing, and demand makes accurate predictions difficult.

SUMMARY: CONTRASTS BETWEEN THE GEYSERS AND THE IMPERIAL VALLEY

Geothermal development at The Geysers and the Imperial Valley presents sharp contrasts in the stage of technology development and therefore in the degree to which environmental impacts are understood, salient, and a matter of public concern or controversy.

At The Geysers, electricity has been produced from steam resources since 1960. Developers, regulatory officials, and local residents all know what the environmental effects of geothermal drilling and power plants are--and their experience extends beyond one or two plants to a large-scale development of eleven operating units. Their concerns are not how to reduce environmental uncertainty, but rather how to regulate and control the development so as to avoid unacceptable environmental damage and nuisance. And the actual definition of what is unacceptable depends largely on the values of local residents *and* on whose perceptions are given weight in the regulatory process. Thus the major source of uncertainty in the Geysers area involves the regulatory process--what regulations apply now, how they may change, and how they are implemented.

In the Imperial Valley, on the other hand, the pace of geothermal energy production is currently governed by technical and economic considerations. Regulatory practices and environmental concerns, while potentially important, do not presently have a significant effect on the industry's decisions to develop the resource. However, if the technical and economic feasibility of geothermal power plants is demonstrated and plants are constructed in the Imperial Valley, regulatory and environmental concerns could become key factors affecting the industry's growth.

III. ENVIRONMENTAL UNCERTAINTIES AND PROBLEMS

Typically, geothermal energy production is considered a relatively clean process which inflicts little damage on the environment. Certainly, the environmental impacts of electricity production from geothermal resources are geographically limited. Unlike coal or nuclear processes, for example, resource extraction and electricity production both occur in the immediate vicinity of the resource itself--eliminating multiple impacts on multiple sites.

But the localized nature of geothermal energy production also means that its environmental consequences vary from place to place and cannot be ranked objectively on a general scale. They are a function of the interaction between the technology appropriate for the kind of resource involved (steam or hot brines) and the unique physical, economic, and demographic characteristics of the local site. Furthermore, local awareness of environmental problems is largely determined by whether or not actual damage has occurred as a result of geothermal development. And local evaluation of their significance will be affected by the degree to which the development complements or conflicts with the local economy and lifestyle.

Our treatment of environmental problems at The Geysers is guided by an assessment of which issues have generated the most public concern. However, the corresponding discussion for the Imperial Valley lacks such a base for comparing potential impacts. Given the nascent stage of development in the Valley, neither the experts nor the average citizen has certain knowledge of how geothermal operations will affect that area. Hence we have judged the potential seriousness of environmental effects in the Valley by assessing, first, the likelihood of their occurrence; second, the state of present abatement technology; and third, the degree to which unabated impacts would conflict with the area's economy and lifestyle.

CONTRASTS BETWEEN THE GEYSERS AND THE IMPERIAL VALLEY

As Table 2 indicates, the problems occurring in the Geysers region are likely to be the least serious in the Imperial Valley, while those

Table 2

COMPARISON OF ENVIRONMENTAL PROBLEMS IN THREE COUNTIES: OCCURRENCE AND SERIOUSNESS

Environmental Problem	Lake County		Sonoma County		Imperial County		
	Occurs	Has Generated Opposition ^a	Occurs	Has Generated Opposition ^b	Might Occur	Potential Seriousness	Has Generated Opposition ^c
Land degradation	Yes	1	Yes	No	Yes	Low	No
Air pollution	Yes	2	Yes	No	Yes	Low	No
Noise pollution	Yes	3	Yes	No	Yes	Low	No
Water pollution	Yes ^d	No	Yes ^d	No longer	Yes	Low to moderate	No
Land subsidence	No ^e	No	No ^e	No	Yes	High	No
Induced seismicity	No ^e	No	No ^e	No	Yes	Moderate to high	No
Water scarcity	No	No	No	No	Yes	High	No

^aThe numbers indicate which problem has generated the most active organized opposition, from highest (1) to lowest (3).

^bHere we mean opposition from within the county itself. H₂S emissions and noise pollution from Sonoma's geothermal development have generated heated opposition from Lake County residents but not from Sonoma residents.

^cHowever, both county officials and environmentalists have expressed concern about the potential for land subsidence. In addition, there is considerable uncertainty about the availability of sufficient water for large-scale geothermal operations.

^dAlthough accidental spills from geothermal operations occur fairly frequently (between May 1974 and August 1977, approximately 19 spills were reported to the Regional Water Quality Control Board), they have not generated organized opposition recently.

^eNo subsidence or seismicity has been attributed to geothermal drilling in The Geysers Known Geothermal Research Area (KGRA) to date.

that could result in moderate to severe environmental damage in the Valley are either nonexistent or of little consequence in The Geysers. These contrasts are a result of differences in the technology required for steam and hot brine resources as well as differences in the physical and socioeconomic characteristics of the two areas.

For example, in The Geysers area, the air is relatively pure. Hydrogen sulfide (H_2S) emissions from the power plants not only exceed ambient air quality standards, but the odor can easily be detected by local residents. In contrast, some projects planned for the Imperial Valley involve reinjection of the cooled brines and noncondensable gases. This fact, combined with the prevalence of strong odors from feed lots and controlled agricultural burning, suggests that any H_2S emissions from geothermal development are less likely to be noticed by the local Valley residents.¹

Similarly, degradation of the land by geothermal plants and equipment conflicts sharply with the scenic beauty of the mountains in Sonoma and Lake counties; the flat lands of the Imperial Valley are not considered as aesthetically appealing.²

The problems of seismicity and land subsidence, which generate concern in the Imperial Valley, are insignificant in The Geysers area. In the steep mountains of Lake and Sonoma counties, any subsidence that may have occurred naturally is not noticeable.³ But in the flat valleys

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¹However, since development to date has been insignificant, it is premature to forecast this environmental factor. Axtmann (1975) calculates that the H_2S emission rate at Cerro Prieto, Mexico (which lies in the Salton Trough south of the Imperial Valley) is substantially higher than that at The Geysers. H_2S emissions vary according to plant location; e.g., H_2S in the East Mesa Known Geothermal Resource Area (KGRA) will probably be considerably lower than at The Geysers, but will be higher in the Salton Sea KGRA. In some areas of the Valley, the hydrogen sulfide content of steam from wells drilled one mile apart has varied by a factor of four to five (communication with Lawrence Livermore Laboratory (LLL) air quality analyst, May 1977).

²One exception to this statement is the desert sand dune area near Glamis and Dunes, where several environmental groups are trying to prevent damage to the desert by dune buggy enthusiasts.

³A study of microearthquakes in The Geysers area after production was under way concluded that the activity was naturally induced. Similarly, geothermally induced subsidence has not been experienced in The Geysers.

of Imperial County, land subsidence or induced seismicity could seriously disrupt the irrigation and drainage canals on which the agricultural economy depends. Both problems are also more likely to occur in Imperial because of the greater volume of the hot brine resource that must be withdrawn to produce an amount of electricity equivalent to that produced from a vapor system.

Finally, while waste waters can be disposed of by reinjection in both areas, the feasibility of reinjecting large volumes of waste brines in the Imperial Valley is still uncertain. If reinjection is not feasible, disposing of waste brines will present formidable problems. But because reinjection is necessary to avoid both subsidence and surface water pollution, the condensate is unlikely to be available as a cooling water source. Hence, finding adequate cooling water supplies in the arid valley could constitute a major obstacle to large-scale development of the resource.

ENVIRONMENTAL PROBLEMS IN THE GEYSERS

As Table 2 indicates, the major environmental problems experienced at The Geysers involve hydrogen sulfide emissions, noise, and land disturbance. Other problems such as water pollution or blowouts have either been corrected or have not generated significant local concern.

While occasional pollution of surface waters caused by land erosion or fluid escape has occurred, the continual discharge of waste waters into nearby streams has been eliminated by reinjection of the condensate into the reservoir. Similarly, at least two major blowouts have occurred at The Geysers, where drilling on unstable land formations has been common. Although accidental blowouts produce a loud continuous noise and great volumes of geothermal fluid until capped, their impact--like that of periodic water pollution--is intermittent. Local complaints have focused instead on aggravations that are experienced more frequently, such as land disturbance caused by wells, pipelines, and plants; the smell of H_2S ; and the noise of drilling.

Land Disturbance

As one informed observer of geothermal development has commented, geothermal plants are extremely "land hungry" (Hess, 1976). Each 110

Mwe plant requires 15 to 20 wells spaced 1/8 to 1/4 mile apart, or approximately one square mile of land.¹ The first 400 Mwe of generating capacity at The Geysers used about 5 1/2 square miles of land; an additional 1100 Mwe would require at least 8 separate plants covering from 6 to 9 square miles (Bowen, 1971). In addition, both the extraction and the generation facilities must be located where the resource is found. This combination of heavy land requirements within a restricted location is likely to produce conflict wherever alternative land uses compete with geothermal.²

In Lake County, where proposed development generates much controversy, such conflicts are exacerbated by the incompatibility of recreational and scenic land use with geothermal plants. Proposed drilling at particularly sensitive sites such as Mount Konocti, the perimeter of Clear Lake, or Boggs and Cobb Mountain has generated the most intense opposition in Lake County--resulting in extended public hearings, court suit threats, and at least three court actions to date. In contrast, where recreational land use is limited, as in the Anderson Springs area, less opposition has surfaced.

Land use conflicts have generated the most intense and irreconcilable opposition to geothermal development in Lake County in the past and are likely to continue to do so in the future.³ Both air and noise pollution can be abated, but geothermal development of scenic or recreational areas means the loss of the land's recreational value for at least 30 years, if not longer. For such blocks of land, the gain of the developer means the loss of the environmentalist, and vice versa.

Hence the central issue in Lake County is not the smell of rotten eggs, which dominates conflicts with its neighbors in Sonoma County, but concern over how the county's land will be utilized. And the key question is whether these zero sum conflicts can be avoided by careful

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¹At present, PG&E does not plan to construct any units larger than 135 Mwe--the maximum size for which a sufficient number of wells can be spaced so that the steam can be efficiently transported to the plant.

²Frequently, however, the undisturbed portion of the area where geothermal wells, steam lines, and power plants are located continue to be used for other purposes (grazing cattle, agriculture crops, etc.).

³Details of these conflicts are given in Appendix A.

land use planning which seeks to preserve highly sensitive areas while realizing the economic benefits of controlled development in less valued locations.

Hydrogen Sulfide Emissions

The California ambient air quality standard for hydrogen sulfide is .03 parts per million (ppm) (Air Resources Board, 1976). This standard is approximately the odor threshold for H_2S . Generally, if one can smell H_2S , the standard is being exceeded.¹ It is frequently exceeded at The Geysers (Tolmasoff, 1976). While there is no problem of toxicity from cooling tower or gas ejector emissions,² the odor is exceedingly annoying to people who live downwind--particularly the Lake County residents.

As mentioned previously, two abatement methods are available. The iron catalyst method oxidizes the H_2S dissolved in the cooling water to elemental sulfur and reduces emissions from the cooling tower by 70 percent at best.³ The Stretford scrubber, using vanadium as a

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¹Both the Lake County Air Pollution Control District and the Northern Sonoma APCD include ambient H_2S standards as part of their general new source review rules. The Lake County APCD's rule 602 specifies "no more than either twenty (20) pounds per hour or one hundred fifty (150) pounds per day of nitrogen oxides, organic gases or any air contaminant for which there is a local, state, or national ambient air quality standard" (Rules and Regulations: Lake County Air Pollution Control District, 1976). The NSAPCD's rule 220 specifies "25 pounds per hour or 250 pounds per day of any air contaminant, . . . , for which there is a state or national ambient air quality standard" (Regulations: North Coast Air Basin & Northern Sonoma Air Pollution Control District, 1975).

²The toxic level for H_2S is 20 ppm (U.S. Dept. of Interior, v. I, 1973). At the wellhead, but not the cooling tower, the average concentration is 200 ppm and the range is between 80 and 3000 ppm. The Industrial Safety Code defines 20 ppm over 8 hours as the level at which protective equipment is required. Even then, the danger is confined to workers in the immediate vicinity of the well--who are protected by the Industrial Safety Code (ISC) regulations as well as by gas ejectors which blow the H_2S away from the work area.

³In units with direct contact condensers, 80 percent of the gaseous emissions stem from the evaporation of the cooling water-condensate solution in which H_2S is dissolved. The other 20 percent comes from the gases ejected from the separator and vented to the atmosphere through stacks.

catalyst, converts the H_2S vapors into sulfur compounds and reduces emissions from the gas ejectors by approximately 98 percent.¹

Although the iron catalyst method works, its operating efficiency is lower than expected and it also corrodes the equipment.² The scrubber is more effective but because it is most efficient with a tube condenser that allows no contact between the steam and the cooling water, it cannot be used on units that have direct contact condensers.

The smell of rotten eggs drifting over the Mayacamas Mountains to Lake County has generated conflict between Sonoma and Lake Counties for at least half a decade. After years of prodding, pressuring, and arm twisting, Lake County officials have finally wrested the first concession from their neighbors to the west. The Northern Sonoma Air Pollution Control District has required PG&E to retrofit Units 3 through 11 as a condition for receiving a permit to construct Units 12, 14, and 15.³

Technical solutions to the hydrogen sulfide problem are available, but abatement will increase the operating cost of old units as well as the cost of new plants designed to use Stretford scrubbers. These added costs, however, should not affect the competitiveness of electricity produced from geothermal steam. The issue is one of *when* and *how* to control H_2S emissions rather than *if*. And the question of timing will be resolved in the political arena--hinging on the balance of power between those pressuring for abatement and those resisting it.

Noise Pollution

Most of the noise pollution at The Geysers occurs during field exploration and development, arising from drilling operations and the

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¹However, approximately 5 to 15 percent of the total H_2S content remains in the condensate and does get released from the cooling towers.

²Iron solids can also plug reinjection wells and may harm the reservoir.

³Units 1 and 2 are too small (11 and 13 Mwe) to create an odor problem. Planned Units 13 through 15 have been designed to use Stretford scrubbers. See Appendix A, Fig. A.1, for location of units.

escape of steam during well testing. Once the field is producing, the noise level generally declines to an acceptable range.¹

Although the controversy over geothermal development in Lake County includes the noise pollution issue, if that were the only environmental impact the controversy would probably recede. Mufflers have already mitigated the most disturbing sounds; county regulations prohibit drilling during the evening hours; and operating power plants do not generate unacceptable noise levels.

But the odor of hydrogen sulfide is a by-product of the power plants that does not disappear when the field has been developed. Nor can it be confined within a limited radius or restricted to certain hours of the day. These emissions bother more people over a wider area and for a longer period of time. Noise contributes to the annoyance but is not sufficiently irritating to stimulate much opposition on its own.

ENVIRONMENTAL UNCERTAINTIES IN THE IMPERIAL VALLEY

In the Imperial Valley, perceptions of the environmental consequences of geothermal development are either tentative or nonexistent. Because development is limited, little is known about how much impact geothermal power plants may have on land subsidence, seismicity, air or water pollution, or vegetation. And not much of The Geysers experience nor that in other areas of the world is directly applicable to the Imperial Valley.

Since little is known about environmental effects and no damage has been experienced to date, public opposition to geothermal

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¹While the noise may be acceptable to humans, it may still be detrimental to wildlife in the area. In 1975 the U.S. Fish and Wildlife Service, together with the California Department of Fish and Game, proposed the establishment of four "critical habitat zones" in the vicinity of the KGRA to protect the population of American peregrine falcons, which had dwindled from 100 known nesting pairs in the 1940s to 10 known nesting pairs in 1969. The 2009 acre area around Cobb Mountain in Lake County is in the direct path of geothermal development, and several companies have already begun exploratory drilling (U.S. Fish and Wildlife Service, 1975). However, since the falcon has not nested on Cobb Mountain for the past three years, it may be withdrawn from consideration as a critical habitat.

development on environmental grounds is virtually nonexistent at present. On the official or "expert" level, however, considerable funds and effort are being expended to monitor existing operations and to develop an information base on which to make reasonable judgments about environmental and energy tradeoffs.

Major Resources and Environmental Problems

Geothermal energy must coexist with two major resources in the Imperial Valley. The economy centers around agriculture, with over a half million acres under cultivation producing a gross value of over \$550,000,000. Since the climate has typical desert characteristics (high temperatures, low relative humidity, and scant precipitation), agricultural cultivation depends on an extensive man-made irrigation and drainage canal system. Disruption of this system could affect the livelihood of many Valley residents as well as the major source of county revenues.

The second major resource is the Salton Sea, California's largest inland water body and the principal location for boating and fishing in the county. Other than the Salton Sea (and some delicate desert areas unlikely to be affected by geothermal), the area has few aesthetic or recreational amenities to be preserved. But the sea itself is already threatened by excessive odors and salinity levels caused by drainage from the Valley's agricultural ditches and two rivers.¹ These levels are presently so high that the fish in the sea may not be able to reproduce, and tourist activity is declining. Dumping waste brines into the Sea is presently prohibited by law and is not likely to be allowed in the future.

The major environmental problems likely to arise in the Imperial Valley involve land subsidence, induced seismicity, scarce water

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¹The Salton Sea is a closed sump fed by ground water and irrigational runoff from the canals and the New and Alamo Rivers. It has no outlet; water leaves the Sea only by evaporation. The Sea is currently slightly more saline than ocean water, a condition caused by evaporation coupled with continual runoff from agricultural leaching procedures. The salinity of the Sea was 3.8 percent in 1972 and is increasing by .08 percent per year.

supplies, and water pollution. Of less potential significance are air and noise pollution and aesthetic damage.

Subsidence and Seismicity

While subsidence and seismic activity are not a major concern at The Geysers, they are more likely to cause damage in the Imperial Valley. Land subsidence is the most likely threat, for it has occurred in other flat valleys where energy from geothermal brines is converted into electricity.¹ The withdrawal of fluids from sedimentary rock structures (like those underlying the Valley) brings about a drop in pressure, causing compaction of the rock and resultant surface subsidence. Hence geothermal operations could induce localized subsidence in the area.²

The main threat of subsidence involves rupturing the extensive gravity-flow irrigation system on which the agricultural economy depends. The crops are irrigated with Colorado River water brought in by a carefully contrived system of canals. Damage to these canals or drainage tiles underlying the fields could disrupt the agricultural operations and thereby diminish county revenues and jobs.

The most commonly discussed "cure" for subsidence is reinjection of waste brines into underground reservoirs. However, in other locations high pressure injection of fluid into wells has induced seismic activity.³ Low pressure injection has been carried out successfully at the Salton Sea geothermal field, but it has not been tested on a large

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¹For example, substantial subsidence has been detected at Wairakei, New Zealand. Total movement has been greater than 4 meters, and the total area affected involves some 65 square kilometers.

²Subsidence is more likely in areas like Heber and East Mesa where the resource is cooler (communication with Union Oil engineer, January 1978).

³Fluid injection at the Rocky Mountain arsenal was linked with a series of earthquakes near Denver in the 1960s. However, that was a case of injection, not reinjection, so it is not directly applicable to the Imperial Valley. Fluid injection at a California oil field adjacent to a reservoir resulted in lubrication of underground faults, a series of micro-earthquakes, and subsequent ground rupture of the dam's clay lining (Hamilton and Meehan, 1971).

scale. Because the potential for triggering earthquakes exists when fluid is injected into a previously faulted and subsidence-stressed surface, the possibility of induced seismic activity cannot be dismissed.

Micro-earthquakes are common in the Imperial Valley; the issue is whether reinjection of geothermal brines might cause or prevent larger earthquakes. Some scientists believe reinjection will relieve stress and prevent major earthquakes; others believe it will induce seismicity of sufficient magnitude to disrupt the Valley's canal system.¹

Thus the problems of subsidence and seismicity are inextricably linked in the Imperial Valley; i.e., the cure for the former may induce the latter. They share other similar features as well: it is difficult to separate the induced occurrence of either from natural phenomena; both pose some threat to the Valley's agricultural economy; and both are presently difficult to predict. One prediction is certain, however. If either is induced by geothermal operations and causes substantial damage to agriculture, geothermal development in the Valley will be severely limited by citizen intervention and county regulations.

Water Pollution and Supply

Water resource availability is considerably more critical in the Imperial Valley than at The Geysers and could constitute an obstacle to large-scale development. All of the irrigation water for the Valley's crops come from the Colorado River, which is already overappropriated. Hence water for cooling or reinjection must come from other sources such as the steam condensate, the drainage ditches, the New and Alamo Rivers, or the Salton Sea.²

For flashed steam systems, the first option is the most attractive as it would avoid the problem of using the brackish waters from the other three sources. However, high evaporation rates or blowdown

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¹For more detail on these two positions, see U.S. Department of Interior (1973), Jet Propulsion Laboratory (1976), Ward and Bjornsson (1971), and Hamilton and Meehan (1971).

²Because of scarce water supplies, the California State Water Resources Control Board and the Imperial Irrigation District have adopted a policy encouraging the use of brackish water for power plant cooling.

discharges could necessitate the use of supplemental waste waters for cooling. But these sources have their own unique problems: how to dispose of saline blowdown waters, how to reduce corrosion of cooling tower equipment, and how to avoid increasing the Salton Sea's salinity. In addition, the economic feasibility of these water supply options has not been proved (Layton, 1976).

All three are considerably more brackish than the Colorado River. The Salton Sea's water is currently approaching 40,000 ppm total dissolved solids (TDS); waste waters carried into the New and Alamo Rivers have a concentration of about 2700 ppm TDS; and dissolved solids in drainage ditches sometimes exceed 4000 ppm TDS (Pimentel, 1976). In any evaporative cooling system, the salinity of the circulating water increases. When it reaches approximately 4000 ppm TDS, the excess salts are discharged into a drainage ditch. But the blowdown associated with using brackish waters for cooling would exceed the waste discharge standards of the Regional Water Quality Control Board (RWQCB).

Consequently the blowdown water would have to be discharged into a lined evaporation pond or reinjected (Layton, 1976). The first option could conflict with county planning standards designed to reduce the amount of arable land disturbed by geothermal projects (Imperial County, 1971). The second option is attractive but has not yet been shown to be technically feasible.

Using brackish waters for cooling also raises problems of cooling tower corrosion and further concentrating the dissolved solids in the Salton Sea.¹ The first problem requires a technical solution; the second could become a political issue since further increases in the Sea's salinity would conflict with efforts to protect the Sea's fish from adverse impacts. The problem is indeed difficult: if too much water drains into the Sea, rising sea levels cause draining and flooding problems; if too little water drains into the Sea, it could become too saline to support animal life.

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¹The use of ditch or river waters (which would otherwise flow into the Sea) for cooling would increase the Sea's salinity and lower the sea level. However, the latter effect could be beneficial as recent sea level rises have threatened homes and waterfowl habitats.

Finally, the economic feasibility of using brackish waters has not been proved, and the possibility of subsidence mentioned earlier may require complete reinjection of all the fluids extracted from the reservoir. The cost of transporting water to sites located far from the sea, rivers, or ditches could reduce the competitiveness of a resource that is already only marginally competitive with other electricity sources. If total reinjection is required, the only sources available for cooling would be the brackish waters described above.

In sum, critical water supply problems could develop if the condensate has to be supplemented with other waters for cooling or if all geothermal fluids have to be reinjected to prevent subsidence. As Layton (1976) has concluded in his analysis of water supply constraints on geothermal development in the Valley, "the timing and severity of future dilemmas will depend on the rate of geothermal development, the type of energy technologies implemented, and the nature of the [institutional] constraints that evolve."

Geothermally induced water pollution is considerably less significant in the Imperial Valley than problems of water supply. Accidental spills constitute the most probable source of surface water pollution, but the effects are likely to be highly localized. Close control of the engineering design and construction, as well as careful monitoring of the equipment, should reduce the likelihood of such contamination.

Other potential water pollution problems in the Imperial Valley are associated with reinjection. While the chemical constituents of the brines vary from one area in the Valley to another, there is enough salt, silica, ammonia, boron, arsenic, and mercury in the wastes to militate against any discharge into the Valley's canals or two rivers (which run into the already highly saline Salton Sea).¹ To avoid

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¹The standards of the Regional Water Quality Control Board prohibit the deposit of spent geothermal brines into either the Salton Sea or the surface water. Release of geothermal fluids into the drainage ditches and thereby into the Salton Sea could compound the Sea's existing problems of excessive salinity and rising level. Discharge of liquid effluents into the ditches could cause fish and turtle kills, thereby upsetting the aquatic ecosystem and precluding recreational fishing in the drain. Accidental blowouts, spills, or seepage from the wells could destroy nearby crops.

pollution of the surface canals, rivers, or sea (as well as subsidence of the land), the brines will have to be reinjected into nonproducing wells.¹

Reinjection has been successfully carried out at The Geysers, but only 20 percent of the steam withdrawn from the reservoir is reinjected. The rest is evaporated. In the Imperial Valley, however, the ratio of water to steam at the wellhead is generally four to one. Consequently, far greater volumes of fluid would have to be reinjected. Since experience with reinjection on such a large scale is nonexistent, there is some uncertainty about how to avoid accidental surface water pollution or reinjection into the water table.² As with spills, this uncertainty can be reduced by design and construction controls. Nevertheless, careful monitoring of reinjection is mandatory to anticipate and control accidents.³ If geothermally induced water pollution resulted in damage to the Valley's crops or drinking water, opposition to geothermal operations would naturally develop.

Air Pollution

The hydrogen sulfide content of the steam in the Valley's hot water resources appears to vary within a single KGRA as well as from one KGRA to another.⁴ But many developers in the Valley contemplate using a closed-loop system by which the noncondensable gases, along

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¹Brine evaporation ponds are not currently feasible for full size power plants (55 Mwe or more) because the waste volume is too large.

²Wells drilled in shallow aquifers supply farmers near the East Mesa KGRA with potable water. Drilling into or near one of the numerous faults in the area could result in contamination of the aquifers, as could casing failures or seismic destruction of existing geothermal wells. However, because of the limited supply of potable ground water in the Imperial Valley, the potential for accidental pollution of surface water is of greater concern to developers and residents alike.

³Related reinjection problems include possible adverse effects of cool water reinjection on the reservoir temperature, additional demands for cooling water if geothermal waters are reinjected, and precipitation of salts and silica in the well caused by lowered temperatures and pressures (Pasqualetti, 1976).

⁴Communication with air quality analyst, Lawrence Livermore Laboratory, July 1977.

with the cooled brines, will be reinjected. Thus gaseous emissions are likely to be lower in the Imperial Valley than in The Geysers. Moreover, existing hydrogen sulfide emissions in the Valley do not exceed Air Resources Board (ARB) standards, and geothermal operations that emit limited amounts of hydrogen sulfide are unlikely to be halted to prevent further degradation of air quality standards.

Nevertheless, any air pollution damage suffered by the half billion dollar agricultural business would be serious. But the danger looks minimal at present. While heavy concentrations of hydrogen sulfide are harmful to vegetation, recent research indicates that the more naturally occurring mixture of H_2S and CO_2 appears to be beneficial to growth (Shinn et al., 1976). Similarly, concern about "acid rains" induced the grape growing county of Napa to enact ordinances severely limiting exploratory drilling.¹ But such rains are considerably less likely to occur in the Imperial Valley because of the arid climate, lower levels of H_2S in the brines, and the closed-loop systems being considered. In fact, water vapor emissions from the cooling towers could cause beneficial changes in the Valley's relative humidity (Kelly, 1977).

Noise Pollution

Noise pollution is also unlikely to be a serious problem in the Imperial Valley. Because wells there are drilled with mud, the drilling noise is considerably lower than at The Geysers where most drilling uses compressed air (Tolmasoff, 1976).² Mufflers are used for periodic well testing, reducing the decibel level to a range between 55 and 65 at 1500 feet--or close to that of normal speech (Anderson, 1976). In

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¹This ordinance has since expired and been replaced by regulations permitting controlled geothermal development.

²Unmuffled mud drilling has a decibel level of 75--similar to the noise experienced at a street corner in a large city; compressed air drilling has a decibel level of 130--similar to that of a jet takeoff. In The Geysers only the upper hole is drilled with mud. Because of the hardness of the rock, the hole is drilled with compressed air in the intermediate section and during the production phase. This phase normally lasts about one week (Tolmasoff, 1976).

addition, the county restricts drilling to the hours between 7 a.m. and 7 p.m., further reducing the probability that noise will be perceived as a major problem by the Valley's citizens.

It should be noted, however, that some geothermal operations are adjacent to wildlife and bird refuges. Noise could affect the balance of nature in these areas by driving away certain species and causing alterations in normal mating and nesting practices.¹ Noise could also disturb penned farm animals that do not have the choice of leaving the area. Whether these problems will occur as a result of geothermal operations is not well understood at present. If they do, they are unlikely to cause major citizen opposition to development. But they may stimulate pressure from state and national wildlife agencies for more effective noise abatement or careful siting.

Land Degradation

Unlike The Geysers area, the Imperial Valley has few aesthetic amenities that might be damaged by geothermal facilities. Chief among these are delicate desert areas in the Dunes and Glamis KGRAs, but development there is unlikely.² Hence the major cause of land use conflicts would revolve around incompatibility of geothermal development with existing or future agricultural activities.

While Imperial County has adopted a policy of reducing the amount of arable land affected by geothermal operations, the county has also been enthusiastically promoting the development of a geothermal industry (Imperial County, 1971). The leasing of land for this purpose is either a private decision of the landowner (in which case he has presumably chosen not to cultivate the relevant acreage) or a decision of the state or federal government (in which case the land was not

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¹A study is currently under way to determine the possible effects of geothermal development on the Yuma clapper rail. Findings suggest that the secretive, highly sensitive bird will be bothered by any human involvement near its nesting area. Hydrogen sulfide is not thought to be a problem, but interference by equipment and machinery could threaten this endangered species.

²Of the six KGRAs in the Imperial Valley, only four (the Salton Sea, Heber, East Mesa, and Brawley) have significant amounts of recoverable energy (Nathenson and Muffler, 1975).

necessarily available for agricultural production). We note also that geothermal plants have coexisted with vineyards in Italy for decades.

As long as their crops are not damaged by geothermally induced pollution, subsidence, or seismicity, we doubt that the Valley's farmers are likely to protest about the aesthetic impact of nearby plants.

IV. THE REGULATORY AND ENVIRONMENTAL CONTEXT: AN OVERVIEW

As Sections II and III have indicated, northern and southern California differ in the degree to which their regulatory processes control geothermal development and in how environmental issues impinge on regulatory practices. These differences help shape the general characteristics of the regulatory and environmental context of geothermal development, and those characteristics, listed below, significantly constrain the actions of developers and federal agencies alike:

- o The dominance of local groups--both private and public--over state or federal interests in the environmental/regulatory process.
- o The highly idiosyncratic nature of environmental perceptions and regulatory practices from one area to another.
- o The degree to which environmental perceptions and the associated regulatory process have changed over time.

This section is an overview of the regulatory and environmental context within which geothermal development takes place in California. It describes who the relevant actors are, what environmental conflicts have emerged since 1960 and why, how they have been played out in the regulatory arena, and how the regulatory process has changed over time. The focus is those areas where most development has occurred to date--the private and state lands in Lake, Sonoma, and Imperial counties.¹

DOMINANCE OF LOCAL INTERESTS

The most striking fact about the environmental and regulatory context of geothermal development is the degree to which it is dominated by local interests. Local, as opposed to state, environmental groups have expressed most of the concern about environmental problems thus

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¹Appendixes A and B provide a more detailed description of environmental conflicts and regulatory practices in these counties.

far. Similarly, the regulatory agencies that have the power to veto or modify a proposed well or plant and that have actually intervened on environmental grounds are predominantly local.

The Actors: Environmentally Concerned Citizens and Groups

In California, citizen opposition to geothermal development is highly localized and rarely transcends the boundaries of county jurisdiction. State-wide or regional environmental groups such as Friends of the Earth have expressed little or no concern about the environmental impacts of geothermal development. If anything, they tend to consider it a relatively benign source of energy in comparison to nuclear, coal, or liquefied natural gas (LNG). The major exception is the Sierra Club, which has protested the leasing of federal lands in areas it considers particularly sensitive and, along with the Environmental Defense Fund, was a party to an unsuccessful suit against exploratory drilling near Cobb Mountain in Lake County. California Trout has also expressed concern, particularly about leasing in the Mono-Long County area.

Nevertheless, even the Sierra Club gives relatively low priority to geothermally caused environmental degradation, as witnessed by the minimal involvement of its members in geothermal matters. Only two individuals cover geothermal for all of California, and the above actions were all the result of efforts by the Northern California representative. While he is personally committed to protecting sensitive areas from development, he is also hard put to find the time to keep up with developments in the whole region and has found it necessary to rely more and more on local groups to intervene in development decisions in The Geysers KGRA. To date, the Southern California representative has evidenced little interest in or concern about geothermal activities in the Imperial Valley.

The reason for the minimal involvement of the state or regional citizen groups in the geothermal picture lies in the nature of the resource itself. Geothermal resources furnish a small percentage of the total energy used in California; moreover, the environmental impacts of geothermal development are largely confined to the location of the

resource and are relatively mild compared with those of coal, oil shale, or nuclear development.¹ Thus, not many people are negatively affected by geothermal development nor are those who are affected exposed to harmful impacts on their health or safety.

When state or regional environmental groups *are* motivated to oppose development, they are often hampered by lack of local support. Both the Sierra Club and California Trout are primarily concerned about the degradation of natural resources, e.g., damage to vegetation, the habitats of fish and wildlife, or an area's scenic beauty. But many geothermal areas are sparsely populated, offering a small base for mobilizing opposition. And for many local residents, the economic advantages of geothermal development often outweigh the environmental costs.

In addition, the environmental groups' natural allies in the government give them relatively ineffectual backing. Agencies whose mandate it is to protect natural resources--in particular, the California Department of Fish and Game and the U.S. Department of Fish and Wildlife--clearly share common interests with the Sierra Club and California Trout and have considerable contact with them. While this alliance is mutually beneficial, both agencies lack enough regulatory power to affect development decisions.² Hence, state or regional opposition to geothermal development is sporadic and frequently frustrated by inadequate local participation or ineffectual agency support.

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¹Compared to coal or oil shale extraction and production, the amount of surface area disrupted to support a 110 Mwe geothermal steam plant is relatively small. Compared to the potential effects of radiation or coal dust on human health, geothermal pollutants are merely a nuisance; they offend the nose but not the body's health or safety.

²Neither the California Department of Fish and Game nor the U.S. Fish and Wildlife has sufficient budgetary resources to conduct well-documented studies of the impact of geothermal development on the environment. Moreover, neither has the authority to deny permits without which development cannot proceed. Their legal authority is largely confined to requesting additional information for environmental documents and suggesting project modifications. Their actual influence depends heavily on the willingness of developers and permit-granting agencies to heed their requests.

Yet the lack of a broad-based state or regional opposition to geothermal development does not mean that there is no concern or that it is ineffectual. It does mean that effective opposition typically requires a local base, and thus far environmental opposition has rarely involved citizen coordination across county lines.

In Napa County, for example, local wine growers succeeded in putting through a moratorium on geothermal development until the county came up with environmental guidelines to constrain development. In Lake County, opposition has coalesced around the Lake County Energy Council (LCEC), an organization of more than 1000 citizens which has already filed two suits against exploratory Environmental Impact Reports (EIR) under the California Environmental Quality Act (CEQA).¹ In Imperial County, only two protests have been recorded--one by a now defunct organization and the other by an unaffiliated individual.² None of these activities in Napa, Lake, or Imperial counties has involved coordination of group efforts across county lines.

Despite this lack of coordination, opponents of geothermal development in particular localities have managed to delay or modify a number of proposed wells or plants. Lake County complaints about the odor of hydrogen sulfide emanating from PG&E's plants in Sonoma led to the imposition of abatement requirements for Units 1 through 11 and delayed the issuance of permits to construct three units. Lengthy EIR hearings, as well as court suits against EIR adequacy in Lake County, have delayed drilling for several months. All but exploratory drilling was stopped in Napa County for about two years.

The impact of these local efforts can be attributed in part to state legislation requiring the preparation and public review of environmental documents for proposed geothermal activities³ and in part

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¹Appendix A provides a more detailed description of the opponents of geothermal development and their activities in Lake County.

²Neither protest was effective in delaying or modifying developer activities, but each received considerable attention from the developer or public agency involved.

³In 1973 the California Environmental Quality Act of 1970 was extended to cover private as well as public projects. Under the law, private intervenors can argue that the environmental reports are

to the fact that local agencies dominate the regulatory process for such development. Citizen intervenors thus can be assured of some degree of local responsiveness to their complaints.

The Actors: Regulatory Agencies

The regulatory institutions involved in geothermal energy development are legion: at least sixteen state, nine federal, and three local agencies have some regulatory or environmental review responsibility for geothermal development (Jet Propulsion Laboratory, 1976). Not all of these, however, have authority specifically related to environmental issues. Nor do all those who have environmental powers exercise them with any regularity. Here we focus on the agencies that dominate the process from an environmental point of view, with particular emphasis on the process as it applies to private and state lands where most development has taken place.

The Regulatory Process for Private and State Lands. Regulatory authority with respect to geothermal development on private and state lands is vested in local and state agencies that issue permits and approvals for various activities--drilling, land use, waste discharge, plant construction, and plant operation.¹

By California Law as embodied in the California Environmental Quality Act of 1970 and its amendments, an Environmental Impact Report or Negative Declaration (ND) must be prepared before any geothermal drilling or power plant construction can start. Local or state agencies that issue permits for drilling or plant construction and operation are involved in the CEQA process either as a *lead agency* responsible for the preparation of environmental documents or as a *responsible agency*² required by law to certify the adequacy of the environmental report.

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inadequate and thereby delay project continuance until adequate information is supplied.

¹Leasing of private lands is not regulated by local or state government.

²A *responsible agency* is defined in the state CEQA guidelines as "a public agency which proposes to undertake or *approve* a project, but is not the lead agency for the project. It includes all public agencies

Geothermal development activities are divided into two stages: geothermal exploration (drilling of exploration and development wells) and geothermal power plant construction. For the exploration phase, the *county* acts as the lead agency responsible for the preparation of an environmental document as a condition for granting its conditional use permit. For exploration on state lands, the State Lands Commission (SLC) is the lead agency, although it typically adopts the environmental document of the county lead agency for leaseholds containing a parcel of state land.

In addition, four responsible agencies must certify the adequacy of the environmental document before granting their own permits or approvals: the local Air Pollution Control District (APCD), Regional Water Quality Control Board (RWQCB), Division of Oil and Gas (DOG), and California Department of Fish and Game (DFG).

For the power plant construction and operation phase, the Public Utilities Commission (PUC) has been the lead agency in the past, requiring an EIR covering construction activities from steam transmission to actual power production as a condition for issuing its Certificate of Public Necessity and Convenience. In the future, the California Energy Resources Conservation and Development Commission (CERCDC)¹ will have responsibility for *siting* both public and private power plants and has the authority to override permit decisions by most other government agencies.² CERCDC will also be the lead agency for preparation of the environmental impact report on the plant and related facilities.

Responsible agencies that must certify EIR adequacy at the plant construction stage include the county government, local APCD, Regional Water Quality Control Board, Division of Oil and Gas, and California

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other than the lead agency which have approval power over the project" (Section 15039).

¹Sometimes referred to here as the State (or California) Energy Commission.

²The Warren-Alquist Act (which established CERCDC) states that the Commission can only certify power plants that will be in compliance with all existing air and water quality standards. Hence, CERCDC cannot override permits issued by the local Air Pollution Control District or the Regional Water Quality Control Board if doing so would result in a violation of air or water quality standards.

Department of Fish and Game.¹ Certification authority for environmental documents is typically based on a prior authority to grant project permits or approvals--such as the county's conditional use permits, the APCD's permits to construct and permits to operate, the waste discharge permit of the RWQCB, DOG's drilling permits, and Fish and Game's streambed alteration agreements.

All agencies mentioned, *except the PUC*, are responsible for preparing or certifying EIRs during *both* stages of geothermal development. All but the Department of Fish and Game can legally veto or modify a project on environmental grounds by refusing to grant project approval or by stipulating modifications in the proposed operations to decrease negative environmental impacts. All agencies, including Fish and Game, can delay a project by requiring additional environmental information before certifying the environmental document as adequate.

The Key Regulatory Agencies. From a legal standpoint, the key regulatory agencies involved with environmental issues for development on private or state lands are the lead agencies for EIR preparation--the county government, the State Lands Commission, and the CPUC/CERCDC--plus the responsible agencies who certify environmental documents and issue their own permits as well. Among the latter, the local APCDs, the RWQCBs, and the California Department of Fish and Game are the most concerned with environmental issues.

But the dominant actors in the regulatory process insofar as both legal powers and actual practice are concerned are the local regulatory agencies--the county governments, the local Air Pollution Control Districts, and the Regional Water Quality Control Boards. Each of these bodies has the power to confer or deny crucial permits at *each* stage of the development process (drilling *and* plant construction), whereas the other agencies play a more restricted role: the State Lands Commission issues leases and prospecting permits only; the California Public Utility Commission certifies the power plants but not the wells; the California Department of Fish and Game does not have licensing

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¹The Department of Fish and Game does not grant permits but it does approve streambed alterations--an authority which is unlikely to be exercised for geothermal.

authority over any wells or plants; and the Division of Oil and Gas has authority over wells but not power plants.

Thus local agencies dominate the regulatory process by virtue of their legal authority over all stages of development, an authority which also makes them key participants in the environmental reporting process. In addition, they dominate the regulatory process by virtue of their strong interest in maintaining (and often enhancing) their legal prerogatives, e.g., the county's power to control land use within its boundaries and the local APCD and RWQCB's powers to enforce air and water standards.

In most California counties where geothermal activities have taken place, county governments have jealously retained the right to issue a conditional use permit for *each* exploratory or development well, as opposed to granting blanket use permits for large areas or establishing geothermal zones. Sonoma County did grant a blanket use permit for Union's entire leasehold, but this practice has not been repeated elsewhere. Similarly, the local air pollution and water quality districts are empowered to enforce state standards, and each devises its own rules and procedures for doing so. They are typically not amenable to suggestions that the relevant state agencies might impose standard enforcement practices on them, and the state agencies do not closely monitor those enforcement activities related to geothermal projects.

Whereas local governments and agencies actively seek to promote or to constrain geothermal development, state agencies have tended to be more interested in other energy sources and to regard geothermal as a limited means of solving the state's energy needs.¹ Furthermore, few state regulatory agencies have shown much interest in placing environmental restrictions on geothermal development, and those that are interested lack the power to enforce their requests.

The Department of Fish and Game, which expresses environmental concerns more frequently and intensely than any other state department

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¹Early in 1978 the Governor's office and the Energy Commission voiced a preference for treating geothermal as a preferred energy source. However, both organizations recognize its limited potential for solving the state's energy problems.

or agency, is limited to requesting additional information before certifying environmental documents. It may also propose "reasonable" modifications in the project, but if they are contested by the operator, the decision is given over to an arbitration panel. Fish and Game's power, therefore, depends on its ability to build a persuasive case for its viewpoint, an ability that is limited by inadequate funds to document past or current impacts on fish or wildlife.

Other state agencies involved in regulating geothermal development tend either to favor its expansion (but not very actively) or to avoid raising environmental questions. The State Lands Commission typically avoids preparing its own EIR by adopting the county document when one is available; the Division of Oil and Gas is primarily responsible for the more narrow question of well safety.¹ The Public Utilities Commission has never denied any permits to construct or operate geothermal plants and strenuously sought to delegate its lead agency role in EIR preparation to local authorities (see Appendix A). The Air Resources Board is only peripherally concerned with hydrogen sulfide emissions because it considers even uncontrolled geothermal plants much less polluting than controlled fossil fuel plants.² Neither the State Air or Water Resources Board has ever revoked a local permit for geothermal wells or plants. Finally, because the State Energy Commission has not exercised its new powers over the siting of geothermal power plants, its posture toward geothermal development is still unclear.³

The dominance of local as opposed to state groups and agencies in regulating the environmental impacts of geothermal development is reinforced by the strong tradition of home rule in California. Even on federal lands, most counties seek to apply their own regulations over land use. While the federal government has not officially recognized their authority, most private developers have complied with county demands. Furthermore, federal law stipulates that where state air and

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¹DOG formerly promoted geothermal development aggressively but has recently adopted a more moderate posture.

²Interview at the ARB, April 6, 1977.

³A more detailed discussion of the Commission's powers and probable intent follows.

water quality standards are as stringent as the national standards (as is the case in California), the state or its designated agencies is responsible for local enforcement. In California, enforcement of air and water quality standards is a local responsibility. Hence the local Air Pollution Control District and the Regional Water Quality Control Board issue their own permits on federal lands.¹

Because local groups and local regulators dominate environmental regulation in California, the people with whom state and federal agencies, as well as developers, must negotiate vary from county to county. The dominance of local groups and agencies also means that environmental issues and regulatory practices vary from one county to another.

IDIOSYNCRATIC NATURE OF THE PRESENT REGULATORY AND ENVIRONMENTAL CONTEXT

Variability in the regulatory and environmental context of geothermal development manifests itself in two ways:

1. In the amount and intensity of environmental opposition to development.
2. In the way in which the regulatory process is carried out.

Environmental Perceptions Vary from County to County

Opposition to geothermal development in California counties ranges from nonexistent to highly vocal and activist. For example, in Imperial County, where there has been no actual experience with power plants in operation, people are generally unaware of geothermal activities and unconcerned about potential impacts on the environment. Furthermore, active protests appear to be rare and isolated events in the valley. We found only two instances of geothermally related complaints: one by an unaffiliated individual and one by a now-defunct organization. The first argued that a county plan and guidelines should precede *all*

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¹Except when the operator is a federal agency. County and other local or state agency powers on federal lands are still in flux. But the trend has been and continues to be toward greater local assertiveness.

development, and the second was based on a mistaken belief that geothermal brines would be discharged into the Salton Sea.¹

Official attitudes toward geothermal in Imperial County are more crystallized than those of the general public and, moreover, are generally favorable. Both elected and appointed officials tend to view the resource as a potential source of revenues for the county and want to promote its development.

In Lake County, where experience with operating power plants is also nonexistent, people are considerably more knowledgeable about geothermal, and they are divided on its merits. According to a county-wide sample survey of registered voters, about two-thirds of Lake County residents are in favor of controlled geothermal development (Vollintine and Weres, 1976a and b). The one-third that expresses doubts about geothermal is highly vocal; they have an organization of approximately 1100 members which puts out a newsletter containing information about upcoming hearings and regulatory decisions. The organization has filed three suits against negative declarations by county agencies.

Official attitudes toward geothermal development in Lake County reflect the basic division of sentiment among the citizenry. The Board of Supervisors, two of whose members have leased their own land to geothermal developers, has been consistently in favor of development. The Planning Commission (especially the staff) is less unabashedly positive--it appears to favor development as long as negative environmental impacts are controlled. Hence it denied a conditional use permit for drilling on Mt. Konocti and has sought funds for carrying out a master environmental assessment and land use plan for the entire county.

The Lake County APCD appears to align itself with the controlled development stance of the Planning Commission but is especially concerned about air pollution spillover from Sonoma County (which leads to violation of state ambient air quality standards in Lake).

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¹Imperial County has now developed a geothermal element for its county plan but did not seek to stop development while the guidelines were being prepared. See Appendix B for more details on the attitudes of private and public groups toward geothermal development in the Imperial Valley.

Finally, citizen opposition to geothermal development is not an issue in Sonoma County. No organizations have surfaced to protest specific wells or plants nor has the Environmental Protection Committee set up under CEQA evidenced concern about environmental problems at The Geysers. Official attitudes toward geothermal development are very favorable: as in Imperial County, they view geothermal as a major source of county revenues and typically act to spur development rather than to control it.

The one exception to this official posture of promoting geothermal in Sonoma without concern for the environmental issues is the local APCD officer. While the APCD board appointed by the Board of Supervisors reflects the Supervisors' pro-growth position, the APCD officer's job is to enforce ambient air quality standards. And these standards are being violated by H₂S emissions from PG&E's plants. Furthermore, the Sonoma officer is beset by constant pressure from Lake County to clean up PG&E's operations. The result is a present policy calculated to avoid unduly antagonizing either the Sonoma Board of Supervisors or Lake County's APCD: approval of new units on condition that the dirtiest of the existing units be retrofitted.

This difference in attitudes toward geothermal development from one locality to another is largely a function of two factors: (1) whether or not environmental damage has been experienced; and (2) the degree to which geothermal development conflicts with the local economy, lifestyle, and values. The lack of experience with geothermally induced environmental problems in Imperial County accounts for both the present apathy of the citizenry and the favorable posture of county officials. Where nothing has gone wrong yet and where there are no clear expectations that major development will cause significant problems, there is little incentive for citizen opposition. Consequently, public officials are free to encourage a new industry which could expand the local tax base.

In contrast, environmental damage *has* been experienced in both Sonoma and Lake Counties,¹ but citizen opposition is nonexistent in the

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¹Most of the environmental damage experienced in Lake is the result of development across the county line in Sonoma.

former and intense in the latter. These differences in perception reflect differences in the economic, physical, and demographic characteristics of the two areas. Less than one percent of the population of Sonoma lives in The Geysers KGRA; thus few people see the power plants, hear the noise, or smell the rotten egg odor. Moreover, since very little of the land in the geothermal area is used for recreational or agricultural purposes, no one's livelihood or lifestyle is threatened by the wells and plants. For Sonoma County, geothermal is all benefit and no cost: it yields three to four million dollars per year in additional revenues and disturbs no one's lifestyle or livelihood.

But in Lake County, recreational and agricultural activities are the major sources of county revenue and much of the area devoted to them is in the KGRA. Moreover, a large proportion of the population consists of retirees and part-time residents who place a high value on the scenic beauty, clean air, and quiet of the area. Consequently, either the livelihood (from tourism or agriculture) or the lifestyle of many residents appears threatened by geothermal development.

Still, individual complaints chiefly concern the fact that the county bears the cost of pollution spillovers from Sonoma's plants without receiving any offsetting economic benefits. These zero-sum game aspects of development across the border, coupled with the potential threat within Lake to the tourism business and the residents' enjoyment of the area's isolated beauty and quiet, explain why opposition has developed. The fact that Lake County is one of the poorest in the state and has very little taxable industry explains the pro-geothermal position of those who see development as a means of increasing county revenues.

Differences in Regulatory Practices

The differences in environmental perceptions from one locality to another are reflected as well in the regulatory practices of each county. Each county government devises its own rules and operating procedures for issuing permits and implementing CEQA. In addition, each APCD develops its own new source review rules, and each APCD and RWQCB develops its own methods for enforcing state air and water quality standards.

The result is that the regulatory process varies from county to county. It also reflects the prevailing posture toward geothermal in each locality. In Sonoma and Imperial Counties, where citizen opposition to geothermal is nonexistent, local regulators have been relatively free to follow their own inclinations to promote development. In both of these counties, therefore, the process has been relatively smooth and predictable.¹ But in Lake County, where the opposition is highly vocal, the process is considerably less smooth and routine.

As Table 3 indicates, Imperial County's efforts to encourage geothermal activities are illustrated by the fact that its charges for permits and EIR preparation as well as its processing time for both are the lowest of all three counties. Imperial County officials have also established a "G" zone or zone overlay permitting geothermal development activities in certain areas--a procedure that reduces delay in those locations.² Sonoma County officials have authorized the preparation of a single EIR for an entire leasehold, and the issuance of addendums to the original EIR for each subsequent well--a strategy that reduces duplication of effort and cuts down processing time once the original EIR has been prepared.³ Despite different procedures in both counties, current regulatory practices in each reflect efforts to reduce delay and duplication of effort.⁴

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¹However, pressures from Lake County for abatement of hydrogen sulfide emissions have diminished the ease of obtaining authorities to construct and operate power plants from the Northern Sonoma APCD.

²Applicants for geothermal development projects (as opposed to applicants for an exploratory drilling permit only) in non-"G" zones must apply for rezoning of the area.

³Sonoma County granted a blanket use permit to Union Oil after the preparation of an EIR for the company's entire leasehold. Subsequently, nineteen permits were issued in rapid succession during 1974.

⁴County agency practices are typically complemented by the practices of the local Air Pollution Control District and Regional Water Quality Control Board. In Imperial, for example, neither agency has denied any requested permits. In Sonoma, waste discharge is not a problem as the condensate is reinjected into the reservoir, and until recently, the local APCD paid little attention to Lake County complaints about pollution from PG&E's power plants. However, these agencies are legally required to enforce state standards. Consequently, when those standards are being violated and enough complaints are made

Table 3

THE EIR/PERMIT PROCESS: COMPARISON OF COUNTY AUTHORITY,
COSTS, AND PROCESSES

Item	Imperial County	Lake County	Sonoma County
Local Agencies			
Planning Department	Prepares environmental documents	Same	Same
Planning Commission	Certifies ND or EIR adequacy; issues permit	Same	--
Board of Zoning Adjustment	--	--	Certifies ND or EIR adequacy; issues permit
Board of Supervisors	Can reverse permit decision	Same	Same
Environmental Review Committee	Advisory, reviews EIR	Advisory, reviews EIR	Directs Planning Director to issue ND or EIR
EIR/Permit Costs			
Permit	\$25	\$500	\$75
EIR/ND determination	\$15	\$100	\$500
EIR preparation	\$50-\$200	\$5,000-\$50,000	Variable, up to \$50,000
Engineering inspector	--	\$5,000-\$20,000	--
Hearings			
On Negative Declaration	No ^a	Yes ^b	Yes (minimum notice = 24 days)
On draft EIR	No ^c	Yes (minimum notice = 30 days)	Yes (minimum notice = 38 days)
Processing Time			
Use permit	90-120 days (includes EIR preparation and review)	4 months without EIR preparation; 7-9 months with EIR preparation	32 days minimum without EIR
EIR	90-120 days (includes permit)	6 months minimum	4 months minimum

^aIn Imperial County, hearings are not legally required on Negative Declarations. A decision regarding a negative declaration is published in the newspaper. Ten days are then required to allow interested people to contest it before it becomes final.

^bAlthough not legally required, hearings on Negative Declarations are usually held in Lake County.

^cWhile no hearing is required on a draft EIR, there is a required hearing after an EIR has become final.

In contrast, regulatory practices in Lake County are more ambiguous, reflecting the conflict between pro- and anti-geothermal forces among residents. For example, the concern that rapid or incautious development might downgrade the area's scenic or recreational value is reflected in the Planning Department's cautious approach to the EIR process. Staff members work closely with the EIR consultant to assure that all issues and potential environmental impacts are adequately discussed. Thus they spend more time on EIR preparation than is the case in either Sonoma or Imperial where it is largely left to a hired consultant.

On the other hand, decisions of the Lake County Board of Supervisors reflect the pro-geothermal posture of the developers and large landholders: they have reversed at least one Planning Commission decision to deny a permit and also issued a negative declaration for another well when the Commission felt an EIR was required. The result is an unpredictable and politicized regulatory process in Lake County. Specific decisions by one agency may be reversed by another or held up by an appeal to higher agencies or courts. And this lack of predictability is further exacerbated by citizen intervention in the process---either through protests at hearings or court suits contesting the adequacy of EIRs. Thus Planning Commission hearings on the EIR for a Union Oil well on its Cobb Mountain leasehold lasted nine months, and the court suit delayed drilling for another 11 months. Court suits filed under CEQA contesting two decisions in 1976 (one authorizing a conditional use permit for a proposed Magma well on Mt. Konocti and another allowing Union to drill at Thurston Lake) have also added to the uncertain regulatory environment in Lake County.

The result of local dominance of the environmental and regulatory context is a highly idiosyncratic process from one county to another. Yet the present state of affairs in any of these counties may change. The third general characteristic of the regulatory context for geothermal in California is the degree to which it has altered over time.

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about them, the APCD and RWQCB may be constrained to restrict development which the county government has approved. The Sonoma County APCD officer's efforts to require retrofitting of PG&E plants fall into this category.

PAST CHANGES IN THE ENVIRONMENTAL ACTORS,
THEIR PERCEPTIONS, AND THEIR INFLUENCE

The balancing of environmental goals and energy requirements is inherently a political process in which opposing groups seek to influence decisions to further their own interests. While the drama is often played out in the regulatory or judicial arena, the process is only routine and predictable when there is little conflict between the goal of energy production and the goal of environmental protection.

When opposing interests enter the scene, the outcome depends on many factors: who the interested parties and decisionmakers are, what they want, how much influence the opposing groups can muster, how responsive the decisionmakers are to different interests, etc. All of these factors are highly subject to change over time. Hence both the context and the outcomes of the regulatory process for environmental issues vary as new actors with different values or potential influence enter the arena, or old actors change their viewpoint or their relative power.

FACTORS AFFECTING CHANGE IN CITIZEN CONCERNS

Large-scale geothermal activity in California is relatively recent, going back to 1960 when PG&E's first geothermal steam plant came on line in Sonoma County. Then only a handful of individuals unsuccessfully protested drilling in sensitive areas; today an organization of 1100 citizens has filed at least three court suits against proposed drilling in one county. This increase in environmental opposition results from the increasing scale of development and its attendant environmental consequences, and the lack of economic benefits to balance against environmental costs of development.

Air pollution, noise, and disturbance resulting from PG&E's first two or three units went relatively unnoticed by residents of Lake County. But as more wells were drilled and plants came on line, the visible effects of scars on the mountains and the odor of hydrogen sulfide emissions bothered more and more people. By 1972, the Air Resources Board began receiving complaints about odor from The Geysers, and by 1976 Lake County residents were talking about suing Sonoma County.

The ire of Lake County residents at air pollution spillovers from plants in Sonoma is exacerbated by the fact that they pay all the environmental costs but receive no benefits from PG&E's plants. Revenues from geothermal taxes go to Sonoma, but the odors waft over the ridge to Lake County. In addition, Lake County does not get its electricity from the geothermal operations in The Geysers but rather from hydroelectric power, which was threatened by the recent drought.

Factors Affecting Change in Citizen Tactics and Influence

The tactics and actual influence of citizen intervenors have also changed since the 1960s when unsuccessful protests were rarely followed up by court suits. These changes can be attributed to the lack of response to earlier protests and to new legislation that has greatly enhanced citizen access to the regulatory process.

Until recently, both private developers and public officials in Sonoma either ignored environmental complaints or strongly resisted implementation of mitigation measures. For example, PG&E located some units directly below the inversion layer, thus increasing the odor spillovers to Lake County; it also fought strenuously against retrofitting its units to mitigate emissions. Furthermore, the APCD hearing board in Sonoma reacted to PG&E's pressure by initially granting the utility variances on Units 1 through 11 through 1980. The utility and the regulatory agencies in Sonoma essentially ignored the complaints of Lake County residents, and the Board of Supervisors in Lake County ignored the concern about proposed development in its own jurisdiction. The Board reversed the Planning Commission's decision to deny a permit for a well in one sensitive area and issued a negative declaration for another.

These actions inflamed an already irate group of citizens and led to the formation of the Lake County Energy Council, now the spearhead for citizen opposition to geothermal development. Many members had been active in two earlier (and now defunct) organizations formed to protest geothermal developments. However, this organization claims a

membership of about 1100 citizens, an unusually large number for a county as sparsely populated as Lake.¹

The Council is influential because it represents such a large group of people and employs sophisticated organizational tactics. It alerts members to upcoming hearings and specific environmental issues through a newsletter, effectively dominates hearings, and is also willing to file suits when its protests are unheeded. These activities require a considerable investment of time, energy, or money. And a major stimulus to the members' willingness to make this investment has been the anger and frustration generated by the indifference of private and public decisionmakers to citizen concerns.

Another factor has enhanced citizen influence *and* changed the focus and tactics of intervenor groups: the passage of the California Environmental Quality Act of 1970 and its subsequent application to all discretionary acts of government. CEQA requires a lead agency to collect and make available for review all information pertinent to the true and expected consequences of a proposed development. While the law does not seek to control environmental damage directly, an individual or agency may sue the lead agency and seek an injunction on the grounds that all relevant information has not been included in the report, i.e., that a Negative Declaration or Environmental Impact Report is inadequate. Once it has been determined that adequate information is contained in the EIR, the complainant has no further recourse under CEQA.

CEQA effectively brought environmental concerns into the regulatory process by providing an arena for review of the potential environmental consequences of a project. As a result, most environmental issues are now articulated under CEQA's umbrella. CEQA also enhanced citizen influence by increasing their access to environmental information, thus reducing the costs of learning about and attending public hearings and providing a basis upon which court suits can be filed.

Under CEQA, citizens are granted access to environmental information developed by private consultants or public agencies, information

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¹Approximately 25,000 people live in Lake County.

difficult to acquire before the law was passed. The law also ensures that citizens know where to register their complaints. Public hearings must be held on each environmental document and the location and time of the hearings must be made known to the public--either through the mail or the local newspapers. Since the hearings are held locally, the costs of attending them are substantially reduced.

Finally, while the courts do not rule on the environmental acceptability of a project under CEQA, the mere threat of a suit may deter a developer from going ahead or cause him to modify the project. Furthermore, delays associated with the actual filing of a suit may affect a marginal project such that its profitability declines and continuation is no longer attractive. Each of these features of the legislation either reduces the costs of citizen intervention or enhances the likelihood of achieving a favorable outcome.

Responses to Citizen Protests

The increased level of environmental conflict at The Geysers has not been without results. After years of indifference to Lake County complaints about pollution spillovers, PG&E has agreed to retrofit some of its existing units to reduce H_2S emissions and has designed its new plants to utilize Stretford scrubbers. In addition, the utility recently instituted tests of a promising new copper sulfate process for reducing emissions. Other developers, as well as PG&E, have provided funds for air transport studies which enable county officials to document and predict the path of hydrogen sulfide emissions.

Within Lake County itself, county officials have begun to seek ways of balancing their goal of geothermal development with citizen demands for environmental protection. The Lake County Air Pollution Control Director has organized several Geothermal Environmental Seminars which have brought together developers, federal, state and local officials, and private individuals in the county for information exchange. In addition, the County Planning Commissioner has been directly involved in the several opinion surveys conducted in Lake County. And finally, the County Board of Supervisors appropriated \$10,000 from its small budget for developing a general Geothermal Resource Impact

Planning Study (GRIPS). Originally intended to provide the information needed for zoning the entire county and designating areas considered too sensitive for geothermal development in Lake County alone, this study has now been expanded to involve all four counties in the Geysers KGRA-- Sonoma, Napa, Mendocino, and Lake.

These actions indicate that a more favorable climate for balancing environmental and energy goals now exists at The Geysers. Citizen opposition has imposed sufficient costs on the proponents of geothermal development to spur conciliatory gestures. And the desire of other citizens for increased revenues from geothermal prevents environmentalists from opposing all development. With one notable exception, these cooperative efforts have occurred without the benefit of state or federal intervention.¹ The implication is that the regulatory process in California can adequately balance environmental and energy goals for geothermal resources without recourse to direct state or federal intervention in the process.

THE POTENTIAL FOR FUTURE CHANGE

The changes in who the actors are, their perception of the problems, and their influence in Lake County since 1960 are not atypical. Similar shifts could occur in other areas as well.

Changes at the County Level

In the Imperial Valley, people have not yet experienced any negative environmental impacts from geothermal development. However, if and when they do, the relatively smooth and predictable regulatory process is likely to become unrecognizable. As we noted in Section III, the impacts most likely to cause opposition if they should occur are effects on the water supply, subsidence, and seismicity. Other potential problems such as hydrogen sulfide emissions, noise, or aesthetic degradation of the land are less likely to give rise to environmental opposition.

Thus the continued predictability of the regulatory process in the Imperial Valley depends on the compatibility of geothermal

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¹That exception is discussed in Section V.

development with the predominant agricultural economy. And that compatibility hinges on whether or not large-scale development occurs and whether or not it triggers major earthquakes or land subsidence or threatens scarce water resources. If it does, geothermal will be viewed as a serious threat to the existing economy, and new opponents will arise to contest geothermal development.

Even if future activities do not impinge on the valley's economic well-being or result in perceived damage to its residents' lifestyles and valued amenities, other events could change the present context in which development takes place.

First of all, if the utilization of wet brines becomes economically feasible, the importance of the regulatory process in pacing development decisions will increase. The Imperial County government has already drafted new guidelines and procedures for geothermal activities within its boundaries. For example, the draft Geothermal Element for the Imperial County General Plan restates the county's policy to foster geothermal development while minimizing negative environmental impacts. To this end, the plan calls for a Master EIR which would be incorporated into separate project EIRs, for review of siting to minimize impacts on agriculture, for the exploration of alternate methods of taxing the resource, and for the development of new standards (or the application of existing standards) dealing with air quality, noise levels, drift, thermal emissions, and other potentially hazardous effects (Imperial County, 1977). Each of these policies, if implemented, would alter present regulatory practices in Imperial County.

In Lake and Sonoma Counties, environmental opposition to geothermal has spurred conciliatory actions by developers, utilities, and county officials. Other changes could also occur as a result of efforts to reduce Sonoma plant emissions and to develop a master environmental plan for the four-county Geysers KGRA. Environmental opposition to development in Lake could recede as abatement proceeds in Sonoma. Moreover, if the county should develop a plan for zoning development areas while protecting sensitive locations from geothermal activity, much of the antagonism toward future expansion would be

reduced. In that case, the regulatory process would become less politicized and considerably more stable.

Changes at the State Level

The entrance of new public agencies in the regulatory process and the passage of new environmental legislation will also affect current modes of operation. One new actor already on the horizon is the State Energy Commission. The Commission now has ultimate siting authority over all public and private power plants greater than 50 Mwe on state and private lands in California. But it is not clear whether it will exercise this authority for plants under 100 Mwe or whether it will try to extend its regulatory jurisdiction to development wells--which have in the past been the province of county agencies.

Our conversations with CERCDC staff and commissioners indicate that the Commission recognizes the intensity of local opposition to usurpation of their traditional powers and is unlikely to impinge sharply on county authority. The Commission's growing awareness of the need for cooperation and flexibility in dealing with the counties is also reflected in written documents.

A draft position paper on the Commission's goal and program options for geothermal development outlines seven options ranging from total control to no control. The preferred choice is the fourth option, which calls for a Master Environmental Assessment *jointly* prepared by federal, state, and local agencies at the beginning of a development project, followed by EIR supplements for wells and power plants.

This option is described by the authors as featuring "a total cooperative effort of all involved regulatory agencies" whose "greatest strength" lies in the "area of compromise and cooperation to get the job done." The authors explicitly point out that "its success depends entirely upon the degree of cooperation achieved" (CERCDC, 1977).

The important point about this recommendation is not the precise means by which the Commission may involve itself in geothermal development but the emphasis on cooperation, compromise, and flexibility. The Commission appears to have digested and accepted the fact that unilateral assertion of control is simply not feasible when existing powers

and regulatory arrangements are already in place and strongly defended. Furthermore, in rejecting the notion of total control, the paper recognizes the need for a local interface backed up by a solid commitment to working with, rather than against, local agencies. The emphasis here is on a process that may change over time, as opposed to legal definitions of powers, formal regulations, and sharply defined organizational structures.

Nevertheless, considerable pressure exists for the Commission to exercise greater control over geothermal development. A bill introduced in the state legislature in the spring of 1977 (AB1035) seeks to transfer authority over all development wells and pipelines to the Commission. In addition, the Governor's Office of Planning and Research is on record as favoring substantial changes in the regulatory process, including master environmental assessments prepared jointly by county and state agencies and the exercise of Commission authority over all thermal power plants with a capacity over 50 Mwe as well as over all development wells (Kirkham, 1976).

Whatever the Commission decides, developers seeking permits to build geothermal plants in the next two or three years will be dealing with a powerful new actor in the regulatory environment. At the minimum, they will have to learn about and adapt to the Commission's developing procedures and practice; they may also face uncertainties caused by interagency jurisdiction conflicts. The recent passage of legislation limiting the EIR review period to 18 months injects another element of uncertainty into the regulatory process. This bill, which constitutes the principal example of state intervention in the regulatory process for geothermal, was not motivated by concerns over delays in geothermal permitting. Rather, Governor Brown's successful campaign to secure passage of the bill was spurred by Dow Chemical's decision to abandon plans for a chemical complex on the Sacramento River.

Since the bill clearly restricts the ability of environmentalists to delay development by seeking additional environmental data, it may increase their incentives to resort to adversary court strategies. On the other hand, it may also encourage local agencies to reduce duplication by preparing Master EIRs for the entire county, making more

efficient use of existing data, etc. Given the shakedown period required for the implementation of CEQA, we can be certain, however, that this legislation will bring with it considerable change and adaptation over the next few years.

Clearly, predictions about the exact nature of future changes in the regulatory process for geothermal are hazardous. But we can predict that the present regulatory and environmental context is highly unlikely to remain as it is.

FEDERAL INVOLVEMENT IN GEOTHERMAL DEVELOPMENT

The federal government has had little effect on geothermal development in California. The leasing of federal lands (authorized under the Geothermal Steam Act of 1970) did not begin until 1975, and no geothermal plants have yet been built on federal land. Nevertheless, federal interest in promoting geothermal development has increased as a result of the recent emphasis on expanding the nation's domestic production of energy. The Department of the Interior's leasing program, as well as ERDA's Geothermal Loan Guarantee program, its environmental baseline study and demonstration funding in the Imperial Valley, and its research into new conversion and control processes, all reflect this increased interest in geothermal development.

While the budget allocated to geothermal development activities is small compared with that for coal or nuclear, the involvement of the federal government in leasing, loans, demonstrations, and baseline studies increases the likelihood of its becoming embroiled in conflicts between energy and the environment. Because of the National Environmental Policy Act (NEPA), any federal action likely to significantly affect the environment requires an Environmental Impact Statement (EIS), thereby increasing the potential for environmental opposition.¹ In addition, the development of federal lands may bring to the fore unresolved questions about the jurisdiction of federal agencies in relation to each other as well as to state and local regulators.

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¹To date, environmental opposition to leasing at The Geysers and the Imperial Valley has been minimal, but more intense reactions have erupted over planned sales in less developed areas such as Mono and Inyo counties.

To date, the federal government has largely avoided becoming a symbol of indifference to environmental concerns or a major threat to local authorities. It has done this by funding (or conducting) on-site environmental studies and by encouraging developers to cooperate with local regulatory agencies and local agencies to cooperate with each other. For example, ERDA has contributed funds to on-site testing of new environmental control processes at The Geysers, is currently conducting an environmental baseline study in the Imperial Valley, and has contributed funds (along with the California Energy Commission) for the creation of a four-county planning and baseline study at The Geysers. Officials from DOI have unofficially encouraged developers on federal lands to comply with local air and water quality standards and to seek the relevant permits from local agencies.

This adaptive posture toward local agencies and jurisdictions is most clearly reflected at the Bureau of Land Management (BLM) and ERDA's Imperial Valley project. Local BLM representatives recognize and support the counties' desire to maintain control of their own destinies and feel that the answer to reducing regulatory delays lies in cooperative efforts with the counties. As one BLM representative added, "you cannot force decisionmakers to make decisions that they're not comfortable with."¹ ERDA's Imperial Valley project is unusual in its emphasis on developing and maintaining contacts with local and state groups, both private and official.²

While there are signs that adaptive and cooperative relationships among all three levels of government are developing, it must be remembered that they occur within a framework of natural antipathy: the counties are not about to let either the state or the federal government preempt their control over land use; the state jealously guards its power through environmental legislation which makes it the enforcer of federal standards; the federal government often feels that national interests are being sacrificed in favor of the parochial interests of

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¹Interview at the Bureau of Land Management, Sacramento, April 5, 1977.

²Section V examines the Imperial Valley project in detail.

individual states or localities. Such antipathies are not only inevitable, they are the *stuff of politics* in a federal system.

But the key to the relative lack of intergovernmental antagonism over geothermal development in California lies in the federal government's willingness to avoid preempting local and state authority and to respond to local concerns and priorities. This posture has been greatly facilitated by the existence of local staff (BLM at Sacramento, ERDA at San Francisco, and LLL at Livermore) who understand the realities of implementing federal policies in specific locations. These local representatives can provide information on what those realities are, how they are changing the shape of original policies and plans, and what the grounds for compromise and bargaining may be. As federal interest in promoting geothermal development intensifies, the role of such offices in working out conflicts between federal, state, and local priorities is likely to take on greater significance.

SUMMARY

The advantage of the localized nature of conflicts over geothermal development in California is that they are generally played out in the most relevant arena, i.e., that geographical area most likely to be affected (positively and negatively) by development. Hence the people directly affected by geothermal operations have an influence on decisions that affect them. While conflict may become intense within this arena, it is also contained by the fact that the parties on both sides now recognize the power of their opponents, i.e., that it is not in their self-interest to totally ignore the demands of their adversaries.

The disadvantage of the localized nature of the regulatory process is that it is highly complex and difficult for developers, environmentalists, and public officials to grasp. Numerous permits have to be obtained from agencies at different levels of government; environmental issues and the corresponding regulatory procedures and practices vary over time as well as from one locality to another; and informal practices often change the shape and form of formal rules.

In this context, coordination is difficult, and the costs of obtaining accurate information about (or imposing) environmental and

regulatory constraints on development are magnified. All the actors involved in the resolution of environmental conflicts--developers, environmentalists, and public officials--have the same problems:

1. They need to understand the local context in order to pursue their own interests.
2. They need the capability to adapt to changing conditions and practices over time.

Not surprisingly, these constraints have given rise to numerous proposals to streamline the development process and reduce variability across time and space. These proposals are usually initiated by government officials or industry representatives impatient with development delays caused by environmental intervention in the process. Alternatives like "one-stop permitting" and state or federal preemption of local regulatory authority are frequently viewed as preferable to the present process.

Because a long history of local autonomy in California buttresses local determination to retain (and often expand) existing powers over land use, we doubt that preemption of local or state authority is likely to succeed. However, other less dramatic measures are more realistic. These include efforts to reduce complexity by state or local legislation and/or cooperative intergovernmental efforts. The McCarthy Bill limiting the EIR review period to 18 months is one example at the state level. In addition, steps toward reducing duplication have already occurred within some local jurisdictions. Imperial County has drafted a geothermal element of its general plan which "assures the other involved agencies that the County will not attempt to duplicate regulations or to regulate matters within their jurisdiction" and proposes the preparation of a master EIR for geothermal development which can be incorporated into all the EIRs required for geothermal projects (Imperial County, 1977). Sonoma County authorized the preparation of a single EIR for an entire leasehold of 6000 acres. Currently, the four counties in The Geysers KGRA are trying to set up an intergovernmental planning study to assess the environmental

consequences of development in the area and provide a basis for land use planning and permit procedures.

These efforts suggest that the balancing of energy and environmental goals related to geothermal development is beginning to produce successful outcomes in California. Progress has been made in terms of each of our three criteria--satisfying the parties involved, reducing environmental uncertainties, and facilitating development while protecting the environment.

At The Geysers, environmentalists have prodded utilities and local regulatory agencies into taking measures to mitigate environmental impacts, and the counties have embarked on an effort to promote controlled development. In the Imperial Valley, research is under way to reduce uncertainties about the environmental impacts of geothermal; the county is actively seeking to promote expansion that will "minimize impacts and maximize benefits to the County" (Imperial County, 1977). Both county and state efforts to reduce delays and duplication are geared toward accommodating the interests of those who seek to promote geothermal development. But the localized focus of the regulatory system ensures that those people most directly affected by a proposed development have access to the decisionmaking process and some influence on the outcome.

V. ERDA'S ENVIRONMENTAL ACTIVITIES: THE IMPERIAL
VALLEY AND THE GEYSERS

ERDA's efforts to resolve environmental problems associated with geothermal development in California have centered on activities in two locations. In the Imperial Valley, ERDA is conducting an environmental baseline study under the direction of Lawrence Livermore Laboratory. In The Geysers, it has funded on-site testing of a new process for controlling H₂S emissions and provided funds to set up a four-county environmental impact and planning study. In this section, we ask what lessons can be learned from ERDA's past experience in these two locations.

THE IMPERIAL VALLEY PROJECT

In California, ERDA's major effort to resolve environmental issues has been through the Imperial Valley Environmental Project (IVEP) whose purpose is to "acquire complete understanding of the environmental quality in the Imperial Valley prior to any major developments" in order to ensure that "the development of geothermal resources proceeds on an environmentally sound basis" (Ansbaugh and Phelps, 1976). Unlike many environmental studies, this project seeks to gather together data on *all* aspects of the environment and provide a complete assessment of present environmental conditions against which the future impacts of geothermal development can be measured.

Its efforts are divided into seven categories: (1) air quality, (2) water quality, (3) ecosystem quality, (4) subsidence and induced seismicity, (5) health effects, (6) socioeconomics, and (7) integrated assessment, an important part of the project's goal.

The IVEP is funded by ERDA with day to day responsibility for the research under the direction of Lawrence Livermore Laboratory. Organizationally, it has two unusual features: (1) project decisionmaking is unusually well coordinated through the use of effective communications between three offices--headquarters, the ERDA field office in San Francisco, and Lawrence Livermore Laboratory; and (2) project staff

have encouraged considerable participation of local interests in project planning and implementation. These two features are crucial to the project's acceptance and performance.

Project Relationships in the Imperial Valley

Our interviews with public officials, environmentalists, and industry representatives involved in geothermal development indicate that IVEP staff have successfully avoided antagonizing local interests in the Imperial Valley. Moreover, in many cases they have developed cooperative working relationships with local officials, developers, and utilities.

Throughout our interviews in the Valley, we heard no criticisms of the project's goals, methods, or relationships. Indeed, only one complaint about the project was expressed locally--by an official who felt there had been insufficient contact with project staff until January 1977. However, he readily stated that his immediate superior had had frequent contacts with the project and that IVEP staff had already moved to accommodate his concerns.

Several state and federal officials, however, had specific criticisms of the IVEP which we will discuss later in this section. But in the Imperial Valley itself, the climate is remarkably free of negative feelings toward the project.

Factors Affecting Project Acceptance. To what can we attribute this marked local acceptance of the IVEP? To some extent, the present local context is an easy one in which to work: there is little or no citizen opposition to geothermal in Imperial County, and local officials are enthusiastic about developing a new source of revenue and jobs in the Valley.¹

On the other hand, local officials also want to control development in the county and are not favorably inclined toward state or

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¹In contrast, there has been considerable furor over the proposed Sundesert Nuclear Plant. Hence there is a base for organizing citizen opposition to geothermal if it becomes a threat to the Valley's lifestyle, economy, or valued environmental assets.

federal encroachment on their prerogatives.¹ This could easily lead to antagonism between IVEP managers and local officials. Moreover, an overly solicitous approach to any one constituency--local officials, developers and utilities, or environmentalists--could cause friction with the others.

Yet none of these problems has emerged in the Imperial Valley. The present satisfaction with the IVEP's goals and progress appears largely attributable to the project managers--to their understanding of the local context and their efforts to involve local interests in project planning and implementation.

Project Initiation. The Imperial Valley Environmental Project arose out of ERDA's commitment to help finance San Diego Gas and Electric's geothermal test facility at Niland. One feature of that contract involved an ERDA commitment to undertake the environmental work required for the test facility. It is important to note here that the county did not ask ERDA to undertake this study. ERDA's initial arrangement was with SDG&E alone; expansion of the project to a valley-wide effort covering the major KGRAS in the area was an ERDA initiative.

The way in which the IVEP was initiated could have generated considerable local resentment against ERDA and severely hindered its ability to do the job it had set out to do. It is not difficult to imagine a situation clouded by local frustration and complaints--against federal intrusion, insensitivity to local problems, and a condescending attitude of "we know what's good for you even if you don't."

None of this occurred. Why? In part because project managers did not go ahead with a regional concept until they had consulted local interests, in part because local inputs were solicited during the planning states, and in part because local officials were more interested and involved in an NSF-funded study designed to produce a geothermal element for the county general plan.

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¹Considerable concern has arisen in Imperial County (as well as Lake and Sonoma) over rumors that the California Energy Commission might assert authority over development well permitting.

Early in the planning stage, project personnel met with representatives of the county to ascertain their interest in a county-wide environmental study and their views on what the study should cover. With the assistance of local personnel, they identified gaps in the NSF study which the IVEP could address for the county of Imperial. In addition, county concerns about the potential for duplication of research were somewhat alleviated by the project's comprehensive survey of existing work in the Valley. This survey identified approximately 38 agencies, research organizations, and developers involved in relevant environmental research. Data from each of these projects and from the LLL studies will be incorporated into a single data bank.

Finally, an advisory panel of representatives from industry, local, state and federal government agencies, and one environmental group reviewed the initial project plan. This panel was not heavily involved in project planning and made only minor suggestions about project emphasis.¹ Furthermore, only one of its eleven members represented a local (as opposed to state or federal) agency, and only one represented a private environmental group.

Nevertheless, the review function appeared to satisfy local interests, who had only a limited interest in the project at this point. The local Director of Public Works (who chaired the advisory panel) was already heavily involved as project director in the NSF study and had less time for the IVEP. The Sierra Club representative did not even participate in the advisory panel, largely because the organization has only peripheral concerns about the environmental effects of geothermal development in the Valley. Hence, local demands or investment of time on the IVEP project plan were minimal.

Project Implementation. Once the IVEP got under way, the managers launched extensive efforts to develop cooperative relationships with public officials, industry, and appropriate research bodies. Their

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¹The panel did, however, ask for greater emphasis on problems of water quality and quantity to which LLL responded. In addition, specific criticisms of the "fuzziness" of plans for addressing socioeconomic effects and the integrated assessment and suggestions for specific crop studies and methods of reporting air-quality data have also been taken into account by LLL.

endeavors took three forms: (1) formal and informal communication through workshops, meetings, and phone contacts; (2) contractual transfers of money from LLL to individuals or groups to carry out part of the research; and (3) cooperative exchanges not typically involving monetary transactions.

Formal and Informal Communication. IVEP staff members have participated in a number of workshops and group meetings which enhance staff understanding of the local and state energy environment as well as others' understanding of project goals and methods. For example, in November 1976, LLL held a workshop (for representatives of Union Oil, Chevron, EPA, SDG&E, and EG&G, Inc.) outlining the baseline projects under way for the Brawley and Heber KGRAs. Project staff have attended numerous conferences and hearings--on the environmental consequences of geothermal development, intergovernmental relations, the Kapiloff task force hearings, the Energy Commission's role in geothermal development, etc.

While one cannot draw direct causal relationships between these endeavors and specific increments in project approval, many of these activities have provided the basis for later cooperative exchanges. After the November workshop, Union Oil asked LLL to locate one of its six air quality monitoring stations near the company's development at Brawley and offered the lab access to its wells. EG&G, Inc. later agreed to take aerial and infrared photographs of the Imperial Valley under the aegis of another ERDA-funded research project at no cost to the IVEP.

In addition, considerable informal contact occurs on the phone or during trips to the Valley. The key to all these contacts, formal and informal, is the spirit with which they are conducted. The project coordinators view each contact as part of a continual and dynamic process which helps them to identify and adapt to new problems and concerns. Their efforts to talk with local officials (as well as developers, state and federal representatives, and private citizens) are not empty gestures but real efforts to listen and learn from others.

Contractual Transfers of Money. Another form of cooperation involves LLL's contracts with universities and other research groups for

work under the aegis of the IVEP. As Table 4 indicates, such contracts totaled about \$468,000 in fiscal year 1976.

Subcontract decisions are greatly facilitated by informal communications of the type described above. For example, LLL solicited inputs from the Air Resources Board and the California Air and Industrial Hygiene Laboratory (AIHL) to identify the most appropriate contractor for its airborne particulate work. In turn, this solicitation of advice often leads to other cooperative efforts and contract decisions, such as the ARB's help with recommending appropriate instruments for air quality measurement and formatting data from the air quality stations, and the choice of the Industrial Hygiene Laboratory for instrument cross-calibration.

LLL's contracts provide for work which the lab is not prepared to undertake itself, utilize the expertise of agencies and universities familiar with the area, and often constitute a form of local or state participation in the project which provides direct economic benefit to the receiving agency.

For example, the County of Imperial, the state Division of Oil and Gas, and the U.S. Geological Survey are all involved in installing or surveying monitoring networks to detect subsidence or seismic activity in the Valley. They were performing such activities before IVEP was formed and are familiar with the Imperial Valley. By subcontracting to these three organizations, the IVEP avoids doing work others can do better and earns goodwill as well. However, the hostility of those who wanted but did not get research funding is an inevitable side effect of the allocation of scarce research monies and lies behind many critical judgments of the IVEP which are discussed later.

Cooperative Exchanges. Non-monetary exchanges of assistance and expertise constitute the third way in which the IVEP has built up cooperative relationships in California. We have already mentioned three examples: the location of an air quality station near Union Oil's development at Brawley; EG&G's flights over the Imperial Valley; and the ARB's recommendations of consultants and equipment for the air quality work and assistance in formatting the collected data. Other examples include Pacific Northwest Laboratory's (PNWL) agreement to

Table 4

IVEP RESEARCH SUPPORT CONTRACTS

Subject	Subcontractor	Funds (\$ thousands)
<i>Air Quality:</i>		
Characterization of airborne particulates throughout the Imperial Valley area	University of California/Davis	\$100
Calibration and standardization of air-quality analytical equipment and gases	State of California Air and Industrial Hygiene Laboratory	25
Manpower assistance for air-quality monitoring stations	County of Imperial	16
<i>Subsidence/Seismicity Effects:</i>		
Establishment of a subsidence-monitoring network around the SDG&E/ERDA Test Facility	County of Imperial	12
Installation of a 6-station seismic-monitoring network around the Salton Sea Geothermal Field	U.S. Geological Survey	69
Resurvey of the Imperial Valley Subsidence Detection network. (This represents a contribution to a large network, which is also funded by government agencies and private developers).	State of California Division of Oil and Gas	35
Fiscal impacts in Imperial County due to geothermal development	University of California, Berkeley	16
Leadership, community decisions, and geothermal energy development: Imperial County	University of California, Riverside	20
Analysis of Salton Sea recreational uses and potential impacts from local geothermal development	University of California, Berkeley	7.6
<i>Ecosystem Quality:</i>		
Analysis of solute movement in soils following geothermal brine spills	University of California, Riverside	15
Analysis of pileworm-larval success at elevated Salton Sea salinity	Pomona College	10
Analysis of Yuma clapper rail ecology for Imperial Valley geothermal areas	Arizona State University	10
Analysis of geothermal pollutant effects upon honeybee production and mortality	University of California, Riverside	5
Supplemental fumigation studies of geothermal pollutant effects on Imperial Valley crops	University of California, Riverside	10
Analysis of Imperial Valley crop-water use and a regional comparison	University of California, Davis	3.2
Trace-metal speciation of geothermal brine following contamination of soils	University of California, Riverside	15
Effects on wildlife refuge areas from geothermal development activities, particularly noise	St. Mary's College, Moraga	19
Analysis of Imperial Valley evapotranspiration and crop ecology	U.S. Department Agriculture Brawley Research Station	10
Fish-sampling program in Salton Sea area for baseline characterization	State of California Department of Fish and Game	4.6
Analysis of effects from geothermal power-plant effluents on Salton Sea organisms	California State College, Hayward	26
Imperial Valley crop sampling for baseline characterization	State of California Agricultural extension Service	9.8
Evaluation of toxicity from geothermal brines and pollutants to <i>Gambusia affinis</i>	North Carolina Central University	10
Evaluation of the synergistic effects of hydrogen sulfide, carbon dioxide, and ozone on Imperial Valley crop yields	University of California, Davis	9.9
Workshop on potential ecological problems and needed research in Imperial Valley	University of California, Riverside	9.7

divert some of its effort in heavy metal characterization to the Imperial Valley and the project's access to the Imperial Irrigation District's (IID) detailed records on the Valley's irrigation and drainage canal system.

In some of these cases, notably the EG&G and PNWL examples, the exchange is one-way: each organization is providing a service to the IVEP which is paid for by another grant. In others (the Union, ARB, and IID examples), the exchange is two-way. Union gets data needed for its environmental reports, and the lab gets access to Union's well. LLL receives assistance from the ARB in assuring the technical quality of its work and detailed maps of the IID's canal system. And in turn, the ARB and IID will have access to the project's data on air quality and the chemical composition of canal waters. The fact that the project's contribution to these exchanges involves data in the process of being collected places a heavy burden on its data transfer capacity, an issue discussed below.

The role of ERDA's San Francisco office (SAN) in facilitating all of these cooperative efforts has been crucial. A research organization like LLL is unlikely to have built up a network of contacts among state and local officials, environmentalists, or industry representatives. However, as ERDA's organizational arm on the West Coast, the SAN office has already developed numerous links with the energy community.

Hence SAN could set up initial meetings for LLL staff or provide names of people to contact. As the official voice of ERDA, SAN personnel could lend a legitimacy to IVEP endeavors which the lab did not command by itself. In turn, the project managers have been adept at building on these initial contacts to create constructive working relationships. And the lab's research prestige has enhanced its credibility in carrying out the baseline studies.

Project Continuation. As the baseline studies undertaken by LLL near completion, the project's focus must turn to issues of data transfer. As we have seen, several organizations expect to utilize IVEP data for their own purposes. Moreover, because development is still nascent in the Imperial Valley, the project cannot assess the actual impact of large-scale geothermal operations. Indeed, the project's

major contribution lies in the future--it provides a data base against which the future impacts of development can be assessed. It also provides an informational base on which regulatory agencies can draw when modifying (or enforcing) air and water quality standards or developing planning guidelines and regulations.

Because of this future orientation, project managers must develop effective methods of providing local officials and developers with the results, a job more easily prescribed than implemented. As the project managers know, even the most lucid reports are rarely read from cover to cover, and those containing highly technical information may not even be skimmed.

Two conditions appear to be important for effective data presentation:

1. The project must be designed to answer questions the local actors want addressed (i.e., there must be a market for the data).
2. The consumers' ability to understand technical material and their preference for different modes of presentation must be taken into account.

It is still too early to assess the IVEP's success at data transfer. In the fall of 1976, project managers identified data transfer as a crucial task and began developing plans for its effectuation. Early efforts to bring local actors into project planning and to address unmet data needs have improved the climate for effective information transfer. The involvement of a number of developers and local and state agencies in project implementation enhances their familiarity with its intent and their incentives to utilize the data. To date, the project has departed from the usual mode of deferring publication of research until all knowledge and information have been acquired and analyzed. Hence, although the study has not been completed, data from it have already been used for several other projects.¹

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¹ Examples of the early use of IVEP data include providing information to the contractor writing the EIR for the proposed Heber plant,

Organizational Features of the IVEP

The degree to which the IVEP has developed a thorough understanding of the local context in which it functions and the degree to which it has encouraged local participation in project implementation are key factors in its success to date. However, neither of these characteristics could come to life in the absence of an effective organizational structure. Four organizational features of the IVEP are crucial to its effectiveness:¹ (1) clear authority and legitimacy at each organizational node; (2) promotion and support from headquarters; (3) frequent organizational communication; and (4) the capacity to adapt to changing conditions.

Authority and Legitimacy at Each Node. The IVEP is an unusual blend of ERDA's three organizational components: headquarters, the field offices, and the national labs.² At each of these organizational nodes there is a single coordinator with major responsibility for the project, and each node accords legitimacy to the other two. At headquarters, one person within the Division of Technology Overview (DTO) has major responsibility for the IVEP. At the SAN office, the key coordinator is in the Environment and Safety Division. At Lawrence Livermore Laboratory, the central figure is the project manager. The laboratory has primary responsibility for the technical competence of the work and its day-to-day operations; the SAN office provides an essential liaison between LLL and ERDA headquarters as well as local and state interests; and headquarters exercises ultimate responsibility for the project's budget and quality.

These brief statements of each node's major functions should not be read too literally. It is not precisely *what* each component does that is important but the fact that each has authority to carry out

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to a developer preparing a report for USGS on proposed drilling at East Mesa, and to an applicant for a geothermal loan guarantee.

¹See P. Berman, M. McLaughlin, et al., *Federal Programs Supporting Educational Change*, The Rand Corporation, R-1587-HEW, 7 vols., 1974-1977, and W. Baer, L. Johnson, and E. Merrow, *Analysis of Federally Funded Demonstration Projects*, The Rand Corporation, R-1926-DOC, 1976.

²The AEC/ERDA national laboratories created with national security and basic research missions.

its own work *and* credits the other coordinators with authority for their decisions.

Of central importance for headquarters is the reduction in the number of fingers in the budgetary pie. One person in the Division of Technology Overview was given and exercised responsibility for getting the project off the ground. Moreover, the project was initially funded with reprogrammed money from several Biomedical and Environmental Research (BER) divisions, eliminating the need to obtain time-consuming concurrence from many sections for specific activities. While subsequent appropriations of funds have required approval from appropriate BER personnel, the process has been smoothed by DTO's intermediary role in recommending approval. With the support of the Assistant Administrator backing him up, the DTO coordinator has prevailed more often than not.

Of central importance for LLL and SAN is the delegation of some budget and decisionmaking responsibilities from headquarters. For example, approval authority for subcontracts has been delegated from headquarters to the SAN office. By working closely with SAN, LLL can let subcontracts without prior approval from Washington, a function that the two together can perform more quickly and competently than headquarters. This simple matter of budgetary responsibility enhances the legitimacy of both SAN and LLL in their dealings with developers and local and state officials. When they speak, they are not viewed as puppets controlled by Washington; they have authority to make decisions and to back them up with the resources necessary to carry them out.

Promotion and Support from Headquarters. The key underpinning of LLL and SAN's authority and credibility lies in the degree to which they are supported by headquarters. This support is manifested most concretely by the delegation of budgetary decisionmaking responsibility already mentioned. But it is displayed in other equally important but less tangible ways, particularly in the degree to which the DTO coordinator trusts LLL and SAN to get the job done and vice versa. This trust facilitates productive work because it (1) increases the likelihood of being supported for exercising initiative; (2) decreases the probability of mercurial changes in the support system; and (3) dampens incentives to divert time to self-protective activities. The net

result on the project has been a cooperative three-way exchange--all three coordinators work well together and transmit that productive climate to their subordinates as well.

Frequent Communication. Neither the support nor the authority and credibility necessary for this project's effectiveness could exist in the absence of frequent communication among all three organizational nodes. Contacts between Washington and California are typically carried on by telephone and occur nearly every day. Trips have also been important at crucial decision points. For example, the LLL project manager spent a month in Washington during the planning phase; the DTO coordinator came to California to lend support to the field at a time when its authority was being questioned.

This frequent communication between all three nodes holds the whole operation together. It is the channel through which support is given, responsibilities are divided, and decisions are made. It is also the channel through which new problems and opportunities are identified and met, giving the project the flexibility and adaptability that make it a dynamic effort.

Adaptability to Changing Conditions. From the beginning, the IVEP has been an innovative organizational experiment involving a series of ad hoc and often first time endeavors. These beginnings set the stage for an adaptive approach to problem-solving.

Ad hoc solutions to the initial problems of project funding and coordination have been followed by ad hoc solutions to later implementation problems and opportunities. For example, the IVEP could accommodate Union Oil's unexpected request for siting of an air quality station partly because project managers had developed a flexible decision-making style. It could identify the data transfer issue as crucial because it was not locked into a highly structured management and research plan. It could alter its program to address the California Department of Fish and Game's concerns about the water quality in the Salton Sea (and the loss of habitats along the sea's periphery) because the managers are genuinely committed to producing information that local users want.

On the other hand, the innovative and adaptive nature of the project has also created a series of organizational tensions, most of which arise out of the clash between new and old ways of doing things. For

example, the uncertain and short-term nature of IVEP's funding causes LLL management considerable anxiety, and the lack of total budget control distresses some headquarters personnel. At both LLL and the SAN office, the IVEP coordinators were initially viewed with some suspicion as headquarters employees. In contrast, some Washington staff have expressed concern that the project is too autonomous or does not adequately reflect headquarters policy.

Similar problems are likely to arise whenever there is deviation from the usual organizational patterns. Their emergence creates both opportunity and obstacles--opportunity to demonstrate that an adaptive organizational structure can produce results, and obstacles to the ability to make the quick decisions that an adaptive organization requires.

Criticisms of the IVEP

Most of the criticism of the IVEP to date has come from state and federal officials. Their most frequent complaint is that the project duplicates efforts already being carried out. Other complaints that LLL failed to use the expertise of relevant state or federal agencies came from officials who sought but did not receive subcontracts and whose departments are chronically underbudgeted and consistently disadvantaged by a lack of legal (e.g., permitting) authority over development decisions.¹

The one issue frequently mentioned and not colored by failure to obtain funds concerned duplication of research. Certainly research in the Imperial Valley has proliferated in recent years. Table 5 indicates the large number of organizations and individuals currently carrying out environmental research there. And this list does not include all the work subcontracted by LLL.

LLL has tried to avoid duplicating work being done elsewhere. We have already alluded to the Lab's effort to identify all the environmental data currently available on the Valley and to incorporate those sources into its data base. It is also true that the two largest

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¹We do not mean to suggest that these complaints are not legitimate. But they reflect a more general agency problem of lack of funds and power rather than a specific difficulty with this project.

Table 5

SELECTED LIST OF GROUPS INVOLVED IN ENVIRONMENTAL
RESEARCH IN THE IMPERIAL VALLEY

Battelle Pacific Northwest Laboratories
Brookhaven National Laboratory
California Institute of Technology
California State Department of Conservation, Division of Oil and Gas
California State Department of Fish and Game
EG&G, Las Vegas, Nevada; Santa Barbara, California
Electric Power Research Institute
Imperial County Air Pollution Control District
Imperial County Department of Public Works
Imperial Magma Corporation
Jet Propulsion Laboratory
National Science Foundation
Pomona College, Pomona, California
St. Mary's College
San Diego Gas & Electric Company
Southern California Edison Company
Systems Control
Systems, Science and Software
Union Oil Corporation
University of California at Davis
University of California at Los Angeles, Radiation Laboratory
University of California at Riverside
University of California Field Agriculture Station
University of Southern California
U.S. Bureau of Reclamation
U.S. Department of Agriculture, Imperial Valley
U.S. Fish and Wildlife Service
U.S. Navy, El Centro Meteorological Group

research efforts in the area, those being funded by LLL and NSF, have different missions. The NSF-funded work (helping the County's Planning Department develop a geothermal element for its land use plan) is based on knowledge currently available, whereas the IVEP project is engaged in data gathering (collecting and analyzing new information on the area's air and water quality, seismic and subsidence patterns, ecosystems, etc.).

Nonetheless, concern about duplication of effort, while technically incorrect, is not without merit. It reflects a more basic concern that the project is too broad or that it is developing data no one will ever use. Indeed, what will be done with the reams of information being generated by LLL and its subcontractors is a question worth considering.

This worry is all the more valid in view of the slow pace of geothermal development in the Valley. Much of the project's work involves generating baseline data on the Valley's physical characteristics against which future changes caused by geothermal development can be compared. But if the County's geothermal resources are not commercially utilized or are utilized on a limited scale, the comparisons will not be very relevant. And, if the resource does become commercial on a large scale, who is going to generate the new information and compare it with the baseline data?

This latter question goes directly to the issue of data transfer and utilization. Certainly some of LLL's research has already been used to satisfy state and county environmental reporting requirements. Other uses that have little direct relationship to assessing the impact of geothermal development on the county may be found.¹ Whether this happens depends on the needs of other groups and individuals and on LLL's ability to make the information available in a form they can understand.

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¹For example, the Air Pollution Control District can use air quality data to assess the effects of other industrial activities; ecologists can use LLL's work to further their understanding of the effects of increasing salinity on various species of fish. The County can utilize the data as inputs to its decisionmaking about policy toward the Salton Sea, allocation of water for other industrial uses, etc.

ERDA'S EXPERIENCE AT THE GEYSERS

ERDA's major environmental activity at The Geysers involves the provision of a \$20,000 planning grant awarded to a four-county commission.¹ While the funding level is small, the story behind the negotiations provides useful experience for assessing direct federal involvement in local environmental conflicts.

The idea of a regional study that would provide the baseline data necessary for planning future geothermal development at The Geysers is not new. In 1973 and 1974, Sonoma County officials had unsuccessfully sought NSF funding for an overall geothermal evaluation in the area. Subsequently, Lake County officials became more concerned about developing a county-wide plan for development in their own jurisdiction. Recognizing that opposition to uncontrolled development was intense and that the project-by-project approach to granting permits was both administratively costly and unlikely to alleviate environmental concerns, the County sought the help of a private consulting firm in developing an integrated assessment plan. On October 19, 1976, the Lake County Board of Supervisors adopted a resolution endorsing the Geothermal Resource Impact Planning Study (GRIPS) proposed by this firm and established a GRIPS trust fund of \$10,000.

At this point, Lake County officials had not resolved the problem of securing sufficient funds to implement a county-wide environmental assessment and had not sought to expand the work to cover the other three counties in The Geysers KGRA. Their efforts to solve the funding problem led directly to the expansion of the proposed study to include Sonoma, Napa, and Mendocino counties.

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¹ERDA has also provided technical assistance and funds to PG&E for on-site testing of a copper sulfate process designed to control hydrogen sulfide emissions before the steam enters the turbines. Early results suggest that the process may be more efficient than currently available abatement methods. If it is also cost effective, practical problems of mitigating emissions at The Geysers could be substantially reduced and a significant contribution made to reducing environmental opposition in the area. However, since this project has required minimal coordination with environmental groups or local or state officials, we have not used it as a case for examining ERDA's local interface capabilities.

Requests for funding were first made to federal and state officials at the Geothermal Environmental seminar held in Lakeport during late October. In this and later discussions with local officials, ERDA indicated that funding might be provided if the Lake County plan were expanded to include all four counties in the region. Responding to this suggestion, Lake officials initiated a four-county coordination meeting on November 9, 1976. Staff members of the Planning Departments of Lake, Sonoma, Napa, and Mendocino counties, as well as a representative from the California Energy Commission (which had indicated a willingness to provide funds in concert with ERDA), attended the meeting.

In December, the Sonoma County Board of Supervisors passed a resolution endorsing and supporting the GRIPS program. Subsequent resolutions were obtained from Mendocino and Napa counties in early 1977. By May, a GRIPS Commission, composed of six voting members (one each for ERDA, CERCDC, and the four counties), had been formed to retain a consultant to determine the areas of study for an overview study at The Geysers. Sonoma County has been designated the lead agency to administer the funds--\$20,000 from ERDA and \$30,000 from CERCDC.

This chronological report does not at all evoke the drama and tension involved in bringing these four separate counties together on one project. As Section IV made clear, conflicts over H₂S emissions had strained relations between Lake and Sonoma counties for several years. Furthermore, Napa County officials had opposed geothermal development as a possible threat to the wine industry and had only recently ended a moratorium on all but exploratory drilling. Mendocino County had fired its pro-development planning director in the past year. There had been no history of cooperative intercounty activities related to geothermal--only conflict between Sonoma and Lake and isolation of Mendocino and Napa.

Forming a four-county commission among these jurisdictions was indeed a striking political achievement. Its accomplishment can be largely attributed to the attraction of receiving federal and state funding for planning which none of the counties could finance on their own. And much of the credit for facilitating this step toward inter-governmental cooperation goes to ERDA for requiring a regional approach as a condition for receiving funds.

Nevertheless, ERDA's positive role in facilitating the creation of the GRIPS Commission has not been lauded by any of the agencies involved. The counties and CERCDC feel that ERDA's actions were motivated by its own organizational imperatives, i.e., to provide work for the Imperial Valley LLL team by funding a similar study at The Geysers. But the counties are strongly opposed to direct federal intervention in their affairs and feared that if LLL undertook the project they would lose control over its design and end use. Hence they strenuously fought for (and won) the right to choose their own consultant and to determine the acceptability of proposed study activities.

The counties' perceptions of ERDA's motives are supported by three facts: (1) ERDA strongly pushed a management plan under which LLL would be designated as project coordinator, suggesting that only that approach would be likely to receive funding in fiscal year 1977/1978. (2) ERDA limited its initial support for a consultant to be selected by the counties (in consultation with ERDA and CERCDC) to only \$20,000. (3) ERDA subsequently funded an independent LLL analysis of the existing environmental data base and additional data needs in The Geysers region. While the Commission's annoyance with these actions has been partially rectified by a decision to allow the LLL effort to proceed as a joint venture with GRIPS,¹ county officials are still concerned that future decisions and projects will not adequately reflect local concerns. How much money will be forthcoming after the planning grant work is completed, who will get it, and how much control the counties will have over future work is still unresolved.

SUMMARY AND IMPLICATIONS

In the Imperial Valley, ERDA is successfully conducting research that will help reduce uncertainties about the environmental impacts of geothermal development and provide data for future development planning in the county. A major feature contributing to this project's success has been the participation of local interests in its design

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¹ LLL and GRIPS have jointly sponsored several workshops on the area's environmental quality, and as a result relationships between local and federal officials have substantially improved.

and implementation. At The Geysers, ERDA has facilitated the development of a cooperative intergovernmental institution but antagonized local interests by proposing that its own laboratory conduct the integrated overview for which the Commission was formed.

In the first case, ERDA's performance was greatly enhanced by its use of field and lab personnel who both understood the local context and thought it was important to involve local interests in the project. In the second case, the same people failed to understand the intensity of local concerns about controlling their own destinies and generated friction as a result. Why?

It would appear that ERDA's very success in the Imperial Valley led to the desire to repeat it--to use the knowledge and expertise developed by LLL in another arena. The understandable organizational imperative to make efficient use of its staff (and avoid wasting a substantial investment in human capital development) vitiated any serious examination of whether ERDA's contribution was desired, whether ERDA's expertise was necessary to get the job done, or whether ERDA could develop a credible presence in the area.

This experience does not mean that DOE's field office in California should not participate more actively in deciding which projects DOE should merely fund and which it should fund and carry out. The major thrust of our analysis of the environmental and regulatory context in California is that implementing federal policy requires a much greater understanding of the local context than can be developed at headquarters. Clearly this understanding can be more easily provided by the staff of a local office than by headquarters personnel.¹

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¹The degree to which federal/local relationships at The Geysers have improved since LLL and GRIPS began conducting joint workshops further underscores this point.

VI. PRINCIPAL FINDINGS

This analysis has focused on the uncertainties surrounding geothermal development in California, the environmental issues associated with development, the regulatory and political context within which those issues are resolved, and ERDA's past experience in resolving environmental problems. The findings set forth in this section form the basis for the policy recommendations in Section VII.

ENVIRONMENTAL ISSUES AND RESOURCE DEVELOPMENT

It seems logical to assume that knowledge about environmental impacts as well as their nature and political importance is related to the nature and pace of development. Yet many environmental studies treat the subject as though the problems associated with a particular resource were invariant across space and time. Our conclusions about geothermal development suggest that this is not the case:

- o *Uncertainty about environmental impacts is related to the maturity of the technology. Hence different environmental R&D goals are appropriate at different stages of development.*

Where the technology has not been demonstrated commercially, as in the Imperial Valley, numerous questions about its impact on the environment are unanswered. Where it has been demonstrated commercially, as in The Geysers KGRA, the question is not what the impacts are but how to mitigate them.

Consequently, the environmental R&D in the two areas must answer different questions: In the Imperial Valley, the question is how development may affect the environment. In The Geysers the question is how development can proceed in an environmentally acceptable manner, i.e., how unacceptable emissions, noise, and land degradation can be mitigated.

- o *Environmental concerns do not set the pace for development until the technical and economic feasibility of development has been proved.*

While the technical and economic feasibility of the development of vapor-dominated geothermal resources has been established, the

feasibility of producing electricity from hot brines is still uncertain. Our examination of the history of geothermal activity in The Geysers and Imperial Valley indicates that regulatory and environmental concerns set the pace of geothermal steam development but are less crucial for the development of hot brines. The pace of development in the Imperial Valley is governed by technical and economic issues concerning the feasibility of commercial production. Nevertheless, the fact that there are no significant regulatory and environmental obstacles to the development of hot brines now does not mean that such obstacles will not emerge when the technology becomes commercial.

o *The environmental problems associated with geothermal development vary with the kind of resource being developed.*

The major problems associated with geothermal steam systems are hydrogen sulfide emissions, noise, and degradation of the land; the major problems associated with wet brine systems involve the potential for induced seismicity and land subsidence and potential effects on water quality and supply.

This obvious point has important implications. The difference in impacts means that environmental regulations, control technologies, and planning guidelines suitable for one resource cannot be easily transferred to the other. For example, regulations to control landslides are important in the mountainous Geysers area but not in the flat Imperial Valley where the issue is how to regulate and control subsidence. Similarly, iron catalyst or Stretford scrubber controls on hydrogen sulfide emissions from geothermal steam plants are not germane for closed-loop binary cycle systems. ReInjection of the condensate to avoid water pollution is a simple process at The Geysers; in the Imperial Valley, reinjection involves far greater volumes of wastes and the consequent possibility of triggering seismic activity. Land use plans in The Geysers area must take into account the preservation of its highly scenic assets, while in the Imperial Valley the dominant planning concern is protection of the agricultural economy.

These differences in the nature of the environmental problems and the attendant regulations, technologies, and planning guidelines for their mitigation create a highly idiosyncratic regulatory and political process surrounding conflict resolution.

SOURCES OF OPPOSITION

We define opposition as any attempt to prevent, delay, or modify an energy project on environmental grounds. Opposition may be voiced by private citizens acting individually or collectively, or by government agencies and bodies. Our major conclusions about opposition to geothermal development outline who the environmental opponents are, what variables affect their activities, and how one can predict their emergence.

o *The most striking fact about the process of balancing environmental and energy goals for geothermal development is the degree to which the process is dominated by local interests.*

Local, as opposed to state or national, environmental groups have expressed most of the concern about environmental problems to date. Similarly, regulatory agencies that have both the power to veto or to modify a proposed well or plant and that have actually intervened on environmental grounds are predominantly local as well. Even developments on federal land are subject to considerable pressure for compliance with local regulations and permitting authorities. One indication that the federal government recognizes the importance of cooperating with local authorities is the fact that it is common practice for developers of federal lands to obtain local permits.

Hence the people with whom state and federal agencies, as well as developers, must negotiate are local, which calls for a clear understanding of local perceptions and regulations, as well as the ways they actually impinge on development activities.

o *Opposition varies with the certainty of impacts.*

Opposition to geothermal development generally does not materialize unless people have had experience with power plants in operation. In The Geysers KGRA, there is active local opposition to development. Evidence about the impact of geothermal steam development there has been accruing for nearly twenty years and can be generalized from one locality to another in the area. Hence Lake County opponents of development use evidence from geothermal operations in adjacent Sonoma County to evaluate the consequences of development for their own area and to justify individual and organized protests.

However, evidence about the environmental impact of hot brine geothermal development is both limited and subject to considerable uncertainty. Generalizations from The Geysers experience to the Imperial Valley are not very relevant. Nevertheless, the fact that no significant opposition to hot brine development has emerged should not be interpreted as a sign that no opposition will develop if the technology moves toward commercial application.¹

o The degree of opposition is not proportional to the severity of the impacts of an energy source compared with those of other sources.

The severity of environmental impacts is not related in a simple one-to-one way to the extent and effectiveness of opposition on environmental grounds. Geothermal steam development, which is environmentally benign relative to most other sources of electricity generation, has nonetheless stirred considerable opposition. The residents of Lake County do not compare the environmental impacts of geothermal with those of coal or oil shale; rather, they compare its environmental consequences with the effects of no development. Hence federal planners cannot judge the potential for local resistance to development by comparing the relative damage associated with different energy sources.

o The extent of opposition on environmental grounds is related to the perceived seriousness of impacts.

These perceptions are shaped by the degree to which economic interests, lifestyles, and valued environmental resources (e.g., scenic, recreational, wildlife, health, etc.) are threatened. Each of these threats is probably a sufficient condition to cause opposition.

In Sonoma and Imperial counties, none of these preconditions for opposition are met. The developed area in Sonoma is largely inaccessible to tourists, and only a handful of residents might experience negative environmental impacts from geothermal operations. In Imperial, development and data on environmental impacts are too limited for the

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¹ Similarly, significant opposition to nuclear power plants or coal mining operations did not emerge until the public had amassed some experience with an operating industry. However, if people can generalize from the development of one energy resource to a new one (for example, from coal to oil shale), opposition may emerge once plans for development have been announced.

residents to have experienced environmental damage or to anticipate future negative consequences. But in Lake County, all of these preconditions are met--the surrounding area has recreational value that appears threatened by geothermal development, and for many residents, the scenic beauty and quiet of the area are highly valued as an integral part of their chosen lifestyle.

Hence, perceptions of environmental damage vary from one locality to another, which clearly implies that the balancing of energy and environmental concerns at the level of national planning is unlikely to have any mitigating effect on the opposition that arises during the implementation of energy projects.

o The development of opposition to energy projects can be anticipated.

But in order to do so, policymakers must know who is likely to be hurt and who is likely to benefit from the development. In some cases, figuring out who gains and who loses from a project is straightforward. For example, in Lake County those who will be hurt by geothermal development include residents who can hear the noise or smell the hydrogen sulfide; those whose income from tourism might suffer from noise, odors, or unsightly development; and those whose enjoyment of the area's scenic beauty would be diminished by the sight of geothermal plants. Those likely to benefit are people who lease their lands to developers; those who provide or use the public services that geothermal resources might help finance; and residents whose tax bills might increase more rapidly without the revenues from geothermal.

Even in such straightforward cases, however, a good deal of knowledge is needed about the local economy, demography, and values. For example, Lake County residents have opposed geothermal development, but their neighbors in adjacent Sonoma have not. Why? Residents of the developed area of Sonoma number less than 50 and few tourists or hikers venture into its rugged mountains; in contrast, Lake County has a thriving tourist industry and a relatively large retired population who in part choose to live there to avoid noise, odors, and unsightly development.

In other cases, predicting opposition also involves an assessment of the pace and objective consequences of future development. Where

the impacts of development are still uncertain, as in the Imperial Valley, opposition cannot be expected to crop up until later. If opposition does arise, it is most likely to come from the Valley's farmers whose livelihood could be threatened by geothermally induced seismicity, subsidence, water pollution, or crop damage.

PROCESSES OF ENVIRONMENTAL CONFLICT RESOLUTION

As a rule, environmental conflicts over geothermal development in California are not based on uncompromising opposition to any and all development. Usually those who oppose have called for mitigation of specific impacts such as air pollution or the degradation of valued scenic and recreational amenities. Hence there is room for accommodation among all the interested parties.

Nevertheless, environmentalists have found it useful to expand the conflict to the courts as a way of increasing the costs of indifference to their concerns. Such strategies are particularly likely when one party to a conflict lacks legitimacy and bargaining power. By filing suits under CEQA and pressuring for strong enforcement of standards, environmentalists in Lake County have been able to demonstrate their ability to impose costs (in the form of delay, if not ultimate obstruction of a project) on those promoting geothermal development. This strategy has, in turn, increased the costs of indifference and enhanced the incentives for bargaining and accommodation among developers, citizen groups, and local officials.

Our findings about the processes of environmental conflict resolution are based on the past fifteen years experience at The Geysers and reflect our interpretation of the process, actors, and strategies as they have evolved over time. We have divided the findings into two categories:

1. Environmentalist Tactics

- o *Indifference to environmental concerns increases the use of adversary tactics such as court suits, public denunciations, and interventions in regulatory processes.*

The history of conflict between Lake and Sonoma counties over emissions from Sonoma's geothermal power plants illustrates this

proposition. The utility and the regulatory bodies in Sonoma ignored Lake County's concerns about pollution spillovers for years, when careful siting and a genuine commitment to abatement could have defused the issue. Within Lake County itself, the Board of Supervisors antagonized citizens' groups and planners by issuing negative declarations for proposed wells and overturning permit denials. These actions in turn led to the development of a citizen organization opposed to insensitive development, spurred the environmentalists to seek redress through the courts, and enhanced citizen support for such delaying tactics.¹

o Organized opposition to development legitimizes environmental concerns and increases the citizenry's awareness of and ability to protect their interests.

Despite the sporadic nature of opposition to development in Lake County, over the past fifteen years three groups have mobilized to oppose specific projects. Each group has, in fact, been manned by members of the preceding organization and has profited from the experience and knowledge of its predecessors.

The present day Lake County Energy Council is the largest of the environmental organizations that have formed in the area and also the most sophisticated. Its newsletter alerts members to proposed developments and upcoming hearings. At least two lawyers are on its staff. A by-product of fifteen years accumulated experience has been the enhancement of citizen awareness of the environmental impacts of development, the broadening of support for environmental protection, and an increase in the sophistication of opposition tactics.²

o The cost of adversary processes may stimulate cooperation and sometimes the creation of new institutions to solve disputes.

Adversary proceedings or attempts to fight regulatory controls impose costs on all parties to the conflict. They may delay development schedules and result in higher equipment costs or reduce the

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¹See Green (1968, 1972, and 1973) for similar conclusions about the development of another energy resource.

²The increased pace of development in both Sonoma and Lake counties has also contributed to citizen awareness of and support for environmental protection.

realization of profits to the developer and tax revenues to the locality. They also necessitate the expenditure of time, money, and psychic energy by all parties. These costs provide incentives for both sides to seek cooperative solutions to the conflict.¹ Two cases in The Geysers illustrate this proposition.

After years of indifference to Lake County's complaints about pollution spillovers, Sonoma County (in the form of its Air Pollution Control District) responded to pressures for action against Pacific Gas and Electric (PG&E). It did so by making PG&E's permit to construct three units conditional on abatement of emissions from several existing plants. Recognizing that expansion of its facility is contingent on abatement elsewhere, PG&E has stepped up its retrofitting schedule and is currently testing a new abatement process. The cost of pressures from Lake County and delays of new construction exceeded any benefit to be gained from continued indifference to the problem.

In Lake County, citizen opposition to geothermal development has coalesced around an organization of 1100 members. Public hearings have become protracted and volatile, and the council has filed at least two court suits challenging the adequacy of environmental reports. But the escalating costs of conflict have brought both environmentalists and local officials together to fund work toward developing a plan for controlled geothermal development. Initiated by Lake County alone, these efforts have expanded to include all four counties in The Geysers KGRA, with Sonoma designated as the lead local government for the new commission.

o Environmental opposition can be anticipated and accommodated by meaningful dialogue and cooperation between developers, regulators, and citizen groups.

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¹The emergence of environmental mediation groups as well as attempts at direct negotiation between industry and environmental representatives further attests to a broadening spirit of accommodation in the United States. Environmental mediators have been used to resolve disputes in Washington, Massachusetts, Colorado, and Minnesota (*Business Week*, August 30, 1976, pp. 50-51). In addition, year-long meetings between conservationists and coal industry spokesmen have produced concessions on both sides, mutual trust, and respect (Alexander, 1978). These developments are largely attributable to each party's belief that the costs of adversary procedures would outweigh the benefits.

To the extent that environmental damage can be mitigated by careful planning or controls, the opposition can also be accommodated without precluding resource development. For example, hydrogen sulfide abatement, effective muffling, and careful siting of wells and plants could minimize the damage associated with geothermal operations in Lake County and still allow the residents to enjoy the benefits of increased county revenues from geothermal operations.

But such dialogue is unlikely to occur as long as one or more parties to the conflict adheres to an intransigent position, for example, promotes development no matter what the environmental costs, or opposes any and all development. Uncompromising positions are most likely to be maintained when one party lacks the ability to impose costs on the other.

Hence one role of government in resolving environmental conflicts is to redress the balance of power among the disputants, for example, to provide environmentalists access to the decisionmaking process (as was accomplished by CEQA) or to help developers reduce excessive delays (as in the McCarthy Bill). Both of these interventions by the California Legislature have increased the incentives for bargaining between the two groups by altering the degree to which one could dominate the other.

2. Regulatory and Political Processes

- o *Formal regulatory procedures do not dominate process outcomes.*

Knowledge of the laws and formal regulations governing geothermal development is not sufficient for understanding the context in which decisions are made. Informal procedures and practices often constitute the real shape and substance of the regulatory process. For example, while several environmental disputes over geothermal development have been resolved through the formal regulatory process, cooperation is increasing--in the form of consultations with environmental groups on EIRs, the use of conditional permits to set abatement schedules or require additional air quality research, and the development of informal communication channels for resolving problems as they arise during project implementation. Moreover, the practical

application of formal regulations and guidelines varies over time as well as from one county to another. Hence understanding the regulatory and political context in which development proceeds must be predicated on knowledge of *actual* practice as well as on knowledge of legal constraints.

o *The regulatory and political processes surrounding the resolution of environmental disputes that arise in geothermal development are highly idiosyncratic.*

The types of issues that arise, the groups articulating those issues, and the processes by which they are reflected in the regulatory arena are different for steam as opposed to wet brine technologies. They also vary from one county to another even for the same resource and technology. For example, the way the regulatory process for geothermal steam development worked in Sonoma is substantially different from the process in adjacent Lake County.

This variability complicates the task of those who seek to promote geothermal development. Not only must they understand local perceptions and regulations; if they wish to be involved in more than one jurisdiction, they must also learn to work with different actors and adjust to different legal and practical constraints in each county. For these reasons, developing relevant information and contacts is a significant part of the costs of geothermal development in California. For any long-term activity, creating and maintaining a strong capability for communication with local actors is a prerequisite for successful development.

o *The regulatory and political processes through which environmental disputes are settled are subject to continuing change.*

Treatment of environmental concerns has changed rapidly during the past decade. All levels of government have passed major environmental protection measures, often changing and tightening them before previous legislation could be assessed. The role of the courts in interpreting environmental laws and regulations has been extensive, adding still further to the amount of change.

National environmental legislation (e.g., NEPA, Clean Air Act, Water Pollution Control Act) has not standardized regulatory processes

and in some areas has produced more state regulation (e.g., the California Environmental Quality Act). A shakedown period has followed the passage of each new major piece of environmental legislation at any level. Both NEPA and CEQA were followed by several years of near chaos in their application.

In California, the passage of CEQA brought environmental concerns into the regulatory process and provided a major arena for these concerns to be articulated. It also stimulated changes (and delays) in county regulations and practice as each jurisdiction developed its own guidelines for implementing legislation. CEQA and other new laws and regulatory guidelines promulgated by new or old agencies have injected considerable uncertainty into project implementation.

The regulatory process for geothermal will continue to change over time. Currently, for example, it is uncertain how the State Energy Commission will define its role in geothermal development, what agencies will exercise authority over development on federal lands, and how the McCarthy Bill will affect development schedules.

Even if regulations *were* relatively stable, the fact that the resolution of environmental disputes is a *process* means that change is inevitable. New actors and issues arise over time; old actors may change their viewpoint, strategies, or relative influence as one issue recedes and another arises. This variability means that those involved with geothermal development face a constantly changing environment, which places a heavy premium on organizational and individual flexibility and adaptability.

Outcomes

Our use of the term "outcomes" does not imply that the processes by which environmental questions or disputes are resolved in the Imperial Valley and The Geysers have come to an end. Rather, the process of settling environmental disputes may have a continuing series of outcomes, which is likely to continue as long as energy is produced in the area. Sometimes the outcome of a particular issue in dispute is clear, for example if abatement technology for an emission is installed. In other cases, an outcome may be only a temporary pause in a continuing dispute, with the same issue cropping up in different ways.

o *In California, environmental concerns are protected by state and local legislation.*

In the past, environmental concerns have not usually been accommodated until the conflict between energy development and environmental protection is highly politicized and adversary in nature. In California, however, the passage of CEQA and other legislation intended to protect the environment has brought environmental concerns into the regulatory process and forced geothermal developers to internalize some of the environmental costs of development.

Since the application of CEQA to all discretionary acts of government, the general climate for cooperative solutions to environmental conflicts over geothermal development has improved. In the four counties covered by The Geysers KGRA, as well as in Imperial County in Southern California, local governments are actively seeking to develop plans for encouraging geothermal development while protecting the environment. Furthermore, while adversary proceedings still continue in the north, both sides (environmentalists and pro-development groups) recognize the costs of protracted conflict and would prefer cooperative solutions to resolving environmental issues.

We believe that the regulatory process in California does ensure that environmental concerns are brought into geothermal development decisions. Moreover, the arena within which these issues are resolved is local: the people most affected by a decision to proceed or not have access to the relevant decisionmakers. The implication is that the concerns of those most affected by development are met more efficiently by local political and regulatory processes for balancing environmental and energy goals than by state or federal processes.

This conclusion does *not* mean that state or federal laws and regulations are superfluous. Federal and state initiatives like NEPA and CEQA and legislation setting environmental standards have provided the legal structure within which environmental concerns can be addressed. Nevertheless, the procedures by which those laws and regulations are enforced are effectively developed and carried out by local agencies responsive to the will of the local electorate. Direct federal or state involvement in the resolution of environmental issues

could risk complicating a process which now addresses the concerns of all interested parties.

o *In the Imperial Valley, efforts are under way to reduce environmental uncertainties, to develop a plan that allows for controlled development, and to respond to the concerns of citizens and developers alike.*

The IVEP effort is designed to provide the county (and others concerned with geothermal development) with baseline environmental data against which the impacts of future development can be measured. In addition, the county has developed a geothermal element for its land use plan which seeks to promote development within the context of protecting its agricultural economy and lifestyle. Finally, county officials, developers, and other groups working in the area appear responsive to concerns about the environmental impacts of development. County officials and developers alike have paid considerable attention to the isolated complaints registered by individual citizens, and the IVEP staff has developed working relationships with a wide variety of public and private groups in the area.

o *In The Geysers, progress has been made toward accommodating the concerns of the environmentalists.*

Despite the history of conflict between Sonoma and Lake counties and within Lake County itself, disputes over hydrogen sulfide emissions and land use conflicts are moving toward resolution. In the wake of Lake County complaints over pollution from Sonoma, local regulatory agencies have pressured the utility to install abatement technologies. The Sonoma Air Pollution Control officer is genuinely committed to reducing air pollution in his area and has taken steps to avoid being overruled by the APCD hearing board. The utility, recognizing that further procrastination is costly, has redesigned planned units to accommodate Stretford scrubbers, stepped up its schedule for abatement of existing units, and begun testing a promising new abatement process.

Within Lake County itself, local officials have brought developers, regulators, and citizens together in a dialogue about the potential benefits and costs of development and provided seed money for developing a controlled geothermal development plan. While no protests

against drilling at sensitive areas have been successful to date, official reactions to citizen concerns are considerably more promising than in the past. This change is illustrated by the county's expenditure of \$10,000 for initial work on a planning study and by its efforts to secure additional funds for the work.

In addition, cooperation has begun among the four counties affected by geothermal development in The Geysers. This process, while facilitated by ERDA, has been dominated by local rather than state or federal actors. The interest of Lake County, where most new development is planned, in getting this cooperative effort off the ground is indicated by its agreement to let Sonoma be the lead agency in the four-county endeavor.

o Federal efforts to consider the environmental problems associated with geothermal development are relatively more attuned to local concerns and priorities than is the case for other technologies like oil shale.

In particular, the Imperial Valley Environmental Project has involved an extensive effort to solicit local inputs and guidance--from local and state officials, environmentalists, developers, and other research groups. Local officials or citizens express few complaints about the project; criticisms expressed most intensely come from representatives of state agencies who want and have not received federal funding.

ERDA's negotiations to fund a similar project at The Geysers facilitated the creation of a four-county commission to plan for controlled development in the area. Yet this accomplishment was partially offset by ERDA's efforts to secure the project for its own laboratory, which antagonized county officials who wanted to avoid federal control of the project's design and end-use. Here ERDA failed to separate a funding decision from its own organizational incentives to conduct the work.

The IVEP case suggests that the existing organizational elements of the Department of Energy (headquarters, the national labs, and field offices) can be welded into an effective project implementation tool. But the IVEP model is not the only alternative for successful

project implementation nor, as The Geysers case demonstrates, should it be routinely applied to other sites. In Section VII we examine the general attributes of the IVEP that are transferable and methods to incorporate them into different organizational frameworks.

VII. POLICY IMPLICATIONS

Our analysis of the processes of environmental conflict resolution during the implementation of energy projects can be summarized as follows. Environmental opposition generally arises out of local, as opposed to national, concerns. Hence balancing energy and environment goals at the level of national policy is unlikely to forestall opposition when those policies are implemented in specific locations. Moreover, environmental problems, opposition, and processes of conflict resolution differ widely according to place and time. Consequently, efforts to find reasonable tradeoffs between the goal of increasing energy production and the goal of protecting the environment face two major constraints:

1. The need to understand the local context in order to identify the issues and parties involved, to ascertain the options for bargaining, and to find ways of implementing new arrangements within the existing institutional structure.
2. The need to adapt to changing conditions and practices over time.

Understanding the local context and adapting to change both require a local interface capability, at least a group of personnel who can provide headquarters with reliable inputs about the relevant local and state actors, regulations, and interests likely to be affected by a specific program; at most a locally based staff with enough authority to make binding commitments and work cooperatively and flexibly with the relevant parties in project implementation. Federal agencies that lack this capacity will be severely hindered in any efforts to implement their policies, as well as in any efforts to balance environmental and energy goals.

We are not suggesting that the federal government should decentralize all decisionmaking to the local level. And we recognize that local actions to protect the environment may work against national

priorities to increase our energy supply. Clearly, the creation of a new Department of Energy indicates that Congress and the President believe that a strong federal presence is necessary to pursue national interests. Nevertheless, we do feel that the growing salience of environmental concerns throughout the nation and the options for addressing them provided by recent legislation, court rulings, and regulatory practice militate against unilateral federal decisions that ignore environmental interests. Even developers of a relatively benign resource like geothermal have faced fierce opposition followed by subsequent scheduling delays and rising costs.

Hence we think it is more fruitful for the federal government to work *with* local citizens and governments rather than to obviate their interests through fiat or preemption. Our consideration of the options for federal involvement reflects this approach: each option presupposes a spirit of cooperation or negotiation rather than one of federal dominance. This approach avoids injecting conflicts over the federal division of powers into environmental disputes, a not inconsiderable accomplishment. It applies to situations where the federal government is either a direct party to an environmental dispute or an interested observer. And it places a premium on serious analysis of whether specific federal actions are likely to produce successful outcomes.

In this section we discuss the implications of our research for the options available for federal involvement in resolving environmental issues, the criteria by which federal agencies might decide when and how to become involved, and the attributes associated with successful intervention. While the data base is limited, the basic features of environmental conflict resolution identified here--dominance of local (as opposed to national) interests, regulatory and political variability across space and time, change in environmental concerns and tactics--appear typical of energy project implementation throughout the nation. To the extent that this is so, the following policy implications should have significance beyond the immediate example of geothermal development.

OPTIONS FOR INVOLVEMENT

The following diagram depicts the range of options for involvement in the resolution of environmental issues that arise in the implementation of energy projects.

We defined each of these options in Section I; here we clarify their organizational prerequisites.

As one moves from left to right along the continuum, the need for a local interface capacity increases; the tax on federal resources and organizational capacity grows; and the political component of the federal role becomes more important (in the sense that the need for coordinating, facilitating, and persuading becomes more critical).

Disseminating information to those involved in site-related environmental issues requires knowing the local context well enough to identify appropriate audiences and their capacity for understanding technical information. *Decisions to fund projects* (by providing transfer payments or underwriting planning studies) and *to facilitate cooperative endeavors* require considerably more "on the ground" contact than does the provision of information. Knowing what and whom to fund or how to promote cooperation among several public or private organizations requires an understanding of the local context not easily available in Washington.

Conducting environmental studies or environmentally related projects on the site of an energy project requires a still greater organizational capacity, as discussed below under "Attributes of Successful Project Implementation." *Mediating disputes* is the political task par excellence, requiring intimate knowledge of the positions and characteristics of the parties involved, as well as skill in negotiation. An ever-present danger in attempting to mediate a dispute is that one may become a party to it instead. We have no examples of ERDA acting

as a mediator among our cases and would caution against the Department of Energy playing such a role unless all parties request its participation *and* unless the required organizational skills are present.

In some cases, the federal government may be a party to an environmental dispute. This is most likely to occur when it leases land for development or funds or conducts pilot, demonstration, or commercialization programs. In such cases, federal choices are severely constrained but still include some flexibility in terms of directly conducting or funding environmental studies. Furthermore, the options for involvement are not necessarily mutually exclusive: in the course of a pilot or demonstration project, the federal government can facilitate cooperative arrangements between developers, governmental bodies, and environmental groups. In addition, it can conduct its own research to meet NEPA impact statement requirements and can also incorporate local concerns into the study through expanding the research agenda or funding additional work desired by local parties. The goodwill that can accrue from allowing local participants greater control over the process may more than make up for any loss due to some overlapping of effort.

RELATIONSHIP OF DIRECT INVOLVEMENT TO SUCCESSFUL OUTCOMES

Three of the five options listed above--facilitating cooperative endeavors, conducting studies, and mediating disputes--are forms of *direct* as opposed to indirect involvement of federal personnel. Undertaking any one of them involves considerably more organizational flexibility, political acumen, and understanding of the local context than does providing information or funds.

Hence a decision in favor of direct involvement requires careful consideration of whether or not it will facilitate a successful resolution of environmental questions. Our analysis of geothermal development yields three generalizations about how direct involvement relates to environmental issue outcomes.

- o *In the absence of local demand for federal participation, direct federal involvement in the resolution of environmental conflicts is unlikely to achieve successful outcomes.*

The passage of NEPA and related legislation at both federal and state levels has significantly altered the regulatory framework in which energy development takes place. Because of legal requirements and the greater access afforded environmental groups to the courts and legislatures, private companies must seriously consider the environmental consequences of development and have strong incentives to resolve environmental issues without federal intervention. This is well illustrated by The Geysers case, where local and state authorities are armed with considerable regulatory authority; the principal problems revolve around the relationships between the developers, local environmentalists, the counties, and the state; and local officials are fearful of federal dominance. Direct federal intervention either through DOE or its laboratories could risk complicating an already complex process. However, federal assistance in the form of funding efforts to plan for controlled development may be desirable.

o When a federal agency is directly involved in environmental issues associated with implementation, the primary variable affecting successful outcomes is the strength of the interface between the federal agency and the local and state participants.

This means the federal agency regularly communicates and cooperates with local actors so that their interests are incorporated into project planning and implementation. The most notable example of a strong interface between ERDA and local participants among our cases is the Imperial Valley Environmental Project. By close coordination with local developers and public officials through Lawrence Livermore Laboratory and the SAN field office, ERDA established the means whereby local inputs could be made. The creation of a strong interface provided the basis for adaptability and flexibility in incorporating local concerns and settling outstanding issues.

o The most extreme form of direct federal involvement is the preemption of local or state authority. We emphasize that unilateral attempts to simplify the regulatory process by federal fiat are unrealistic.

The complexity of environmental issues and the regulatory processes associated with them put considerable constraints on development:

multiple permits have to be issued for each project; the actors, problems, and procedures vary from one locality to another; and the process changes from one year to the next. Not surprisingly, alternatives like federal preemption of state and local regulatory authority (especially where federal lands are involved) are frequently viewed as preferable to the present process.

But such suggestions are unrealistic in the absence of a greater national consensus on the nature of the energy problem and its solution. The increased assertiveness of state and local governments in energy and environmental issues is part of a larger trend toward greater local control caused by general unhappiness with, or lack of trust in, federal policy. There is little reason to expect that this trend can be avoided in energy development.

However, while streamlining by federal fiat is not likely to succeed, cooperative intergovernmental efforts to reduce complexity are more realistic. Within some state and local jurisdictions, steps toward reducing duplication have already occurred. Where state and local jurisdictions can agree, the regulatory process can be streamlined within and across localities. The federal government can play a role in this process by providing monetary or technical support to cooperative intergovernmental groups.

CRITERIA FOR INVOLVEMENT

The federal government's decision to become involved in resolving environmental issues is often constrained by other factors (such as prior decisions to stimulate commercialization) which have little to do with the appropriateness of a federal role in environmental issues. To the extent that choices can be made, however, we suggest that the following criteria are important.

1. *What are the attitudes of the key local parties toward direct federal involvement?*

When a federal agency's presence and assistance are not desired, it is highly unlikely that it can be useful in providing funds, conducting studies, facilitating cooperative endeavors, or mediating disputes.

2. *To what extent are the financial resources and expertise of the local parties adequate to perform the planning and analysis necessary for dealing with environmental questions?*

If local resources and expertise are generally viewed as adequate, no federal involvement in funding studies is indicated. If resources are inadequate but expertise is available, the federal government may consider funding the necessary studies through local parties. Local people often prefer this route because it gives them control over the money and increases the chances that the money will be used in ways they feel are most important. For several reasons, federal agencies are understandably reluctant to do this: (a) local actors may not use the money in a way they deem proper to their goals or the national interest, and (b) federal agencies often have a clear and understandable interest in using their own personnel. Nevertheless, only when the local parties have neither the resources nor the ability to obtain the requisite expertise should the federal government step in to conduct a study or project.

3. *How well developed are the existing institutions and regulatory processes for dealing with environmental issues?*

If existing processes for allowing access and settling disputes are functioning well, there is probably little that active federal involvement in mediating conflicts can accomplish. Mediating disputes is difficult, especially when a federal agency may be perceived (or may come to be perceived) as having vested interests in the outcome.

4. *How would federal intervention affect the complexity of the process by which environmental issues are resolved?*

The addition of a federal agency to a local process can bring with it a host of legal and administrative requirements (such as additional impact statements, new accounting procedures, hiring guidelines, and reporting requirements) that can materially offset any advantages the agency might offer. The effect may be to reduce the flexibility of local parties, by an amount greater than the value of the federal agency's contribution.

5. *Last, but surely not least, does the agency have the organizational capacity to intervene in the manner contemplated?*

To mediate disputes effectively or to conduct on-site projects and studies requires a substantial political as well as technical presence that is sometimes unavailable to federal agencies. Neither DOE's labs nor its headquarters staff can substitute for an effective political office in a region.

ORGANIZATIONAL IMPLICATIONS

Many criteria suggested above require a knowledge of the local context which is not always available to federal agencies. Even when the federal government is only indirectly involved in site-specific project implementation, it still requires some "on the ground" contact. For example, decisions to fund environmental assessments or planning studies require prior assessments of the following questions: (1) Is the study or project needed? (2) Would it be done without federal funding? (3) Who is best equipped to carry it out? Each judgment requires substantial knowledge of the local setting.

Judgments about attitudes toward direct federal involvement or the capacity of local institutions and processes to effectively resolve environmental issues require even greater sensitivity to local practices and perceptions. No handbook on intergovernmental relations can substitute for the experience gained by personnel who know the relevant actors as well as how the institutions work in practice. We are not suggesting that federal agencies need a site office in every state, but they do need to avoid making decisions to become involved unless their decisions can be based on sufficient knowledge of local concerns and capabilities.

DOE's present structure--headquarters, field offices, and the national labs--is not adequate for this purpose. Headquarters staff are constrained by their physical distance from local sites and by the sheer impossibility of becoming an expert on multiple areas. The labs are basically research organizations and, as such, are generally not equipped to develop and maintain the local contacts required for assessing numerous project proposals, much less local capacities, practices, and attitudes toward DOE. As the Imperial Valley project suggests, the labs may be able to implement a particular local project

in *combination* with an effective field office, but that needs to be clearly distinguished from assuming a wide variety of essentially political tasks in a region.

The field offices are the logical alternatives for developing local contacts, experience, and expertise. But in order to perform this role effectively, field offices need to be appropriately staffed, granted sufficient authority to function as more independent arms of the federal agency, and strategically located.¹ The creation of a new Department of Energy offers the opportunity to initiate a thorough reevaluation of their location and capabilities.

ATTRIBUTES OF SUCCESSFUL PROJECT IMPLEMENTATION

If the federal government is to take an *active* role in project implementation, it must develop a strong local interface. This requires a local presence: a group of project managers and staff who have frequent contacts with local actors and are able to identify and respond to the constraints of the project's local setting.

The basic characteristics associated with successful projects are those that make the Imperial Valley Environmental Project (IVEP) work. They include:

- o Knowledge of local politics, regulatory processes, and issues.
- o Participation by local interests.
- o Promotion and support of the project at headquarters.
- o Clear lines of communication.
- o Capacity to adapt to changing conditions.

It is equally important that *projects not be undertaken largely for the purpose of enhancing or maintaining the federal agency's own*

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¹We emphasize that the act of creating or restructuring DOE's presence in a particular locality necessarily entails some risk of becoming inappropriately involved in local political disputes. Nevertheless, if DOE is to be heavily involved in funding work in a particular region, it must acquire enough knowledge of local capabilities and concerns to avoid inefficient funding decisions. And if it is to be directly involved in implementation activities, it must develop the political acumen to work effectively with local actors.

organizational structure. It is difficult enough to develop constructive relationships with local officials even when there is a considerable effort to accommodate local concerns and priorities. ERDA's initial negotiations for environmental planning studies in the four-county Geysers region were clearly perceived by county officials as biased by an organizational motive to provide work for one of the labs. Even when the federal government's expertise is substantial, such a motive should not be the primary reason for project initiation.

Knowledge of Local Politics and Issues

In the IVEP, Lawrence Livermore Lab (LLL) and the San Francisco field office (SAN) acquired a thorough knowledge of which people and agencies were important in Imperial County and the state, what issues worried local people the most, and what the regulatory environment was both formally and informally. Initial contacts, particularly with developers and state representatives, were facilitated by the SAN office's general experience with California politics and energy development. These contacts were then used to identify key local officials and groups and to continue developing an understanding of local concerns, priorities, and practices. The process was furthered by efforts to stimulate local participation in the project, the second key attribute of the IVEP.

Local Participation

LLL and SAN have encouraged project participation by local and state officials, developers, and environmentalists in three ways: (1) by formal and informal contacts through workshops, meetings, and phone conversations; (2) by contractual transfers of money from LLL to individuals or groups who carry out part of the research; and (3) by cooperative exchanges that do not typically involve monetary transactions (such as the Air Resources Board's inputs on instrument calibration, siting of air quality stations, and the choice of subcontractors).

Most local officials have good feelings about the project because they believe it addresses their needs. The main problem on the horizon

--transferring information from LLL to local people after the project terminates--has already been anticipated. The main source of complaint involves LLL's subcontracts. For example, some state officials are highly critical of the project, an attitude that appears to be closely linked with whether they wanted but did not receive research subcontracts from LLL. These problems are unavoidable when scarce resources are being allocated.

Headquarters Support of the Project

There has been solid support for the IVEP from headquarters, evidenced by considerable delegation of decisionmaking responsibility *and* the ability to expend funds, both of which are crucial to the project's effectiveness. LLL can issue research subcontracts more quickly than headquarters can, and LLL and SAN together are in a better position to assess subcontractor capabilities. It is also important to have someone on site who can speak with authority for headquarters. Without the responsibility for making key decisions *and* the authority to back them up with the force of the funding agency, efforts by the Lab and field offices to solicit local inputs would be meaningless.

Clear Lines of Communication

Finally, the lines of communication between the three organizational nodes--LLL, SAN, and headquarters--are both clear and frequently used. Each office has someone who is responsible for the project, who can give clear signals, and who can insure continuity and coordination. Phone contact between LLL, SAN, and headquarters occurs almost daily; in addition, the principal coordinators have had considerable face-to-face contact at crucial decision points dealing with project initiation and continuity.

It is important to note, however, that clear communication channels would be irrelevant if they were not continually used and buttressed by a commitment to cooperative coordination on the part of all three coordinators. It is this willingness to work together to solve problems and to trust others to do their jobs--this realization of the substance, as opposed to the form, of real communication--that makes the project organizationally effective.

Adaptability to Changing Conditions

From the beginning, the IVEP has been an innovative organizational experiment involving a series of first-time endeavors--the diversion of funds from other projects, the launching of a highly technical laboratory into site-specific field work, and the melding together of these disparate organizational units. These innovative beginnings set the stage for an adaptive approach to problem-solving which has continued throughout the project. In large part, this flexibility and adaptability have allowed the project staff to build working relationships in the Valley, respond to local concerns, and build support for the research.

Our identification of features associated with successful implementation is based on one case. However, studies of federal project implementation in education, housing, energy, health, and transportation have isolated similar characteristics.¹ Such studies have also pointed out that projects which are locally initiated and somewhat insulated from federal political pressures fare better than those directly pushed by the federal government. These findings support our conclusions; they also provide support for our judgment that the findings of this analysis can be applied to energy projects throughout the federal government.

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¹For example, a major study of 293 innovative educational projects identified the following key components of effective implementation: staff training keyed to the local setting; participation by teachers in materials development; support from the superintendent, district officials, and principals; and flexible and adaptive planning coupled with frequent and regular staff communication. Similarly, an analysis of 24 federal demonstration projects concluded that successful diffusion was facilitated by on-site management, local participation in project planning and operations, and the absence of tight time constraints, but was hindered by headquarters' pressure for unrealistic goals (a constraint often associated with heavy federal funding). See *Federal Programs Supporting Educational Change*, The Rand Corporation, R-1589-HEW, 7 vols.; *Analysis of Federally Funded Demonstration Projects*, The Rand Corporation, R-1926-DOE, 1976.

Appendix A

DEVELOPMENT AT THE GEYSERS

by Kathleen Knight

The Geysers geothermal power plant in Northern California is the largest geothermal electrical generating facility in the world--and the only such facility financed entirely by private capital. Installed capacity at The Geysers is 502 megawatts (Mw), produced by eleven generating units in Sonoma County.

The plant is located within the federally designated Geysers KGRA (Known Geothermal Resource Area), a vapor-dominated reservoir underlying approximately 256,000 acres in four northern California counties--Sonoma, Lake, Napa, and Mendocino. The developed portion of the KGRA is in the rugged Mayacamas Mountains of northeast Sonoma County. By far the major portion lies within the boundaries of Lake County, while a finger of the KGRA extends south through Napa and another small portion extends into the western edge of Mendocino County.

While four counties have jurisdiction over portions of the KGRA, little or no development has been proposed to date in Napa and Mendocino. Hence this appendix examines the history of geothermal development in Sonoma and Lake counties. It focuses on those historical aspects with environmental significance: (1) regulatory conflicts within each of the counties; (2) intercounty conflicts over mitigating the environmental consequences of development; and (3) the actors and interest within Lake County where development has so far been fore-stalled.

The story is necessarily complex because of the number of actors involved. It is made more so by the implementation of new environmental regulations and the establishment of new regulatory agencies at several different times.

DEVELOPMENT BACKGROUND

The Geysers was first discovered in 1847. By the 1880s, numerous resorts and spas had been established at hot springs in Lake County.

A resort was also established in Sonoma County, but the rugged terrain deterred all but the most determined tourists from venturing there. At its peak, perhaps 300 persons lived in the immediate vicinity of this resort; the population is now under 50.

Between 1921 and 1925, eight geothermal wells were drilled to produce electricity in Sonoma County but abandoned for lack of a nearby market. In 1955, Magma Power Company began drilling for steam; two years later Pacific Gas and Electric (PG&E) entered into a joint venture with Magma and Union Oil to determine the feasibility of commercial electrical generation from geothermal steam.

Table A.1 indicates the progression of development at The Geysers and the cumulative net capacity. The first commercial facility (11 Mw) came on-line in 1960 and was hooked into PG&E's preexisting grid. Ten additional units were added between 1963 and 1975. All of these units are located in Sonoma County. Unit 12 was originally planned to come on-line in 1975 but was rescheduled to 1978. According to PG&E, this delay will affect the schedule of other planned units as well (Dan et al., 1975).

Figure A.1 shows the location of present and projected units. As the map indicates, the first ten units were sited in pairs. This strategy minimized the area which had to be graded and allowed testing of the early units. With the commissioning of Unit 11, PG&E determined that a 110 Mwe unit was optimal for the steam supplied from this reservoir. Hence all additional units will be approximately this size.

The dark line in Fig. A.1 represents the border between Sonoma and Lake Counties. Unit 13 at Anderson Springs is the only power plant to receive siting approval in Lake County. Twenty-six development wells have been drilled, and the plant is scheduled to come on-line in 1979.

ENVIRONMENTAL PROBLEMS AND PERCEPTIONS

The major environmental impacts of geothermal developments at The Geysers are air pollution (odor and noise) and damage to the natural aesthetic values of the region.

Table A.1

THE GEYERS DEVELOPMENT: PLANNED
AND ACTUAL OPERATIONAL DATES

Unit	Year in Operation	Net capacity (kw)	
		Unit	Cumulative
1	1960	11 000	11 000
2	1963	13 000	24 000
3	1967	27 000	51 000
4	1968	27 000	78 000
5	1971	53 000	131 000
6	1971	53 000	184 000
7	1972	53 000	237 000
8	1972	53 000	290 000
9	1973	53 000	343 000
10	1973	53 000	396 000
11	1975	106 000	502 000
12 ^a	1978	106 000	608 000
14 ^a	1978	110 000	718 000
15 ^a	1978	55 000	773 000
13 ^a	1979	135 000	908 000
16 ^a	1981	110 000 ^b	1018 000
17 ^a	1981	110 000 ^b	1128 000
18 ^c	--	--	--

SOURCE: Adapted from Dan et al. (1976).
Update on planned operation dates supplied
by C. C. Newton, PG&E, June 6, 1977.

^aPlanned operation date.

^bApproximate capacity.

^cUnit 18 is still in the planning stage.
It will be the first power plant to be cer-
tified by CERCDC rather than CPUC.

Fig. A.1--Development at The Geysers KGRA
(adapted from Dan et al., 1976)

Air Pollution, Noise and Land Disturbance

The most frequent cause of citizen complaints is the odor of hydrogen sulfide emitted from the power plants. Characterized as smelling like rotten eggs, hydrogen sulfide emissions are a nuisance but not a toxic problem. Hydrogen sulfide concentrations usually exceed the ambient air quality standard more often during the dry season, especially during the months of December, January, and August. Intensity varies inversely with distance, and little effect is noticed more than ten miles distant from existing 1972 operations (Tolmasoff, 1976).

Under normal circumstances, the H_2S from PG&E's plants is lifted over the ridge by the prevailing winds and dissipates in the upper atmosphere. However, during periods of inversion, it passes through a saddle in the ridge and collects on the floor of Cobb Valley in Lake County. Consequently, complaints about the odor come from Lake County residents, particularly those who live directly in the path of the prevailing transport pattern for hydrogen sulfide.

Most of the noise pollution experienced at The Geysers occurs during field exploration and development. Because the area is so quiet, the sound of drilling and escaping steam is acutely disturbing to those in the vicinity of the steam fields.¹ Nevertheless, mufflers considerably reduce the most disturbing sounds, and drilling is prohibited during the more sensitive evening hours. While it contributes to annoyance caused by geothermal operations, noise pollution is not sufficiently irritating to stimulate active opposition on its own.

Although numerous landslides associated with geothermal operations have occurred in the developed area in Sonoma County, little concern has been expressed over this phenomenon. Local safety regulations prevent drilling during the rainy season; nevertheless, 91 of 168 wells drilled prior to 1974 were located on landslides (Bacon et al., 1976).

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¹Noise from other industrial operations is minimal, for neither the Sonoma nor the Lake County portions of the KGRA have much industry. Lake County's industry consists of a few small furniture and manufacturing concerns. Sonoma County has nearly 400 manufacturing plants, but they are located in the central valley and coastal areas. In The Geysers region of Sonoma's Mayacamas Mountains, the only industries near the steam plants are cattle grazing and a few small vineyards.

In part, this lack of concern reflects the fact that landslides are a frequent and therefore "normal" occurrence in the tectonically active Mayacamas Mountains. In part, it reflects the fact that the area has few residents or visitors who might see the damage.

However, concerns about degradation of the land are the dominant issue in Lake County. The focus of these concerns is not landslides but degradation of areas valued for their scenic and recreational value. Lake County is a relatively undeveloped area popular with tourists and residents for its many scenic and recreational attractions. Among these attractions are Clear Lake, which covers 45,000 acres; Mt. Konocti, an extinct volcano; Boggs Mountain, the location of a state forest; and Cobb Mountain.

Although hydrogen sulfide emissions generate the most complaints from individuals in Lake County, the issue underlying organized opposition to development is really growth--and how growth might impinge on enjoyment of Lake County's unique assets.¹ Concern about potential damage to highly scenic areas is particularly intense, but the proposed development of less scenic spots encounters much less opposition.

Contrasts Between Sonoma and Lake Counties

Despite the fact that Sonoma is adjacent to Lake County, the residents of the former do not complain about geothermal development, while the residents of the latter do. Why? The KGRA portion of Sonoma is also spectacularly beautiful and the air is as pristine as in Lake. But less than fifty people live in Sonoma's part of the KGRA and few tourists or hikers venture into its rugged mountains. Hence few people in Sonoma see the plants, hear the drilling, or smell the gas.

In contrast, approximately 25,000 people live in Lake County, an area whose main sources of employment are tourism and agriculture. Many of Lake's citizens value the area's scenic beauty and quiet; others make their living from tourism and services related to tourism. Geothermal development diminishes the value of living in a quiet,

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¹See below for details of controversies over specific projects proposed for Lake County.

undeveloped, and highly scenic area--both for those who enjoy Lake's attractions for their own sake and for those who base their livelihood on tourism.

On the other hand, about a quarter of Lake's population consists of elderly retired people. While many of these people live in Lake precisely because of its scenic amenities, they are also acutely aware of the pressures to raise property taxes. Lake County is one of the poorest counties in the state. If revenues from geothermal development in Lake rose to the level of those received in Sonoma, they would account for approximately one-quarter of Lake's current budget.¹ Hence feelings about development in Lake County are mixed. Approximately one-third favor it enthusiastically, one-third oppose it, and one-third approve development if it is strictly controlled.

These differences in citizen reactions to development in Sonoma and Lake counties are reflected in the regulatory history of both areas described below.

REGULATION IN SONOMA COUNTY

While Sonoma County's isolated geothermal operations cause its residents no environmental problems, they do constitute its largest single tax-paying entity. These facts suggest that Sonoma County officials would enthusiastically promote geothermal development and avoid initiating any efforts to mitigate its environmental impacts. And such has been the case. From 1960 to the present, Sonoma County has taken action to regulate geothermal only in response to external stimuli--in particular, to pressures from neighboring Lake County to reduce hydrogen sulfide emissions.

Regulation Prior to CEQA

The history of geothermal development in Sonoma County before the passage of the California Environmental Quality Act (CEQA) was relatively unaffected by environmental dissent or concern. Prior to 1968, county permits for exploratory and development wells were issued

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¹\$12,400,000 in 1975 (conversation with Lake County Auditor, June 1977).

expeditiously but on a well-by-well basis. In 1968, the Sonoma County Board of Zoning Adjustments acted to streamline this process *and* to limit its own involvement in decisions regarding geothermal development. It did so by authorizing a blanket use permit for the 6000-acre Union leasehold, thereby eliminating the need for action on each well.

By granting this permit, the Sonoma Board relinquished all discretionary authority over the geothermal development. PG&E then had to obtain permits for constructing and operating electrical generating facilities from only one agency, the California Public Utilities Commission (CPUC). During this period, permits to construct and operate Units 5 through 11 were issued by CPUC. This represented over a five-fold increase in electrical capacity.

Post-CEQA Regulation

In 1973, as a result of a decision in the "Friends of Mammoth" case, CEQA was interpreted to apply to all discretionary acts of government. The legislation requires a designated "lead agency" to collect and make available for review all information pertinent to determining the true and expected environmental consequences of a proposed development. For geothermal exploration and development, the lead agency is the county office, which issues land use permits and variances. For plant certification, the lead agency is the CPUC, which typically incorporates the county's Environmental Impact Report (EIR) in its own document.

However, because the Board of Zoning Adjustment had relinquished its authority over geothermal development, confusion arose over which body would be the lead agency responsible for preparing the EIR. The ensuing dispute delayed certification of Unit 12 more than a year. Under the general terms of CEQA, the County Board of Supervisors would have been the lead agency, but the Board had delegated its permitting responsibility to the Board of Zoning Adjustment, which in turn had issued a blanket use permit in 1968. Therefore, the CPUC was the logical agency responsible for the preparation of an EIR on Unit 12 and its related wells.

However, in 1971 the Northern Sonoma Air Pollution Control District (NSAPCD) was established. This agency also issued discretionary permits under its authority to review new sources of air pollution. CPUC argued that NSAPCD should be the lead agency by virtue of its responsibility to issue Authorities to Construct *prior* to CPUC's issuance of a Certificate of Public Convenience and Necessity. Since NSAPCD had neither the budget nor the staff to prepare EIRs, the function was taken over by the Sonoma County Planning Department until the end of 1975.

Resolving this controversy and assigning responsibility took about nine months. These delays, however, were not caused by environmental opposition to development but by the officials' reluctance to take on a new function that might make them vulnerable to court suits. Both the CPUC and the Sonoma County Board of Zoning Adjustment wanted to facilitate development, not to control it.

The application of CEQA to geothermal development also caused other delays while county and state agencies struggled to devise rules and procedures for EIR preparation and review. Real as these problems were, the corresponding lag between application and certification was a function of learning how to implement a new law, not a function of its use by citizen groups to protect the environment. But, as we shall see below, the situation in Lake County was different. CEQA provided environmentalists there with a tool for combatting development, and they readily made use of it.

The Spillover Problem

Hydrogen sulfide emissions from PG&E's plants in Sonoma do not observe county boundaries but drift over the ridge into Lake County. By 1972, when 8 units were producing 290 megawatts in Sonoma, the California Air Resources Board began receiving complaints from Lake County residents about odor from PG&E's geothermal operations.¹

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¹With the operation of Unit 8, a threshold level of odor may have been reached. In addition, siting plants below the inversion level interferes with the dissipation of H₂S in the upper atmosphere (Tolmasoff, 1976). And all of PG&E's early units are located below the inversion level.

Complaints received by the ARB were directed to the Northern Sonoma Air Pollution Control Officer, who found the Geysers plant in violation of the state ambient air standards for H₂S and issued an abatement order. PG&E immediately sought to avoid complying with the order. Using the argument that abatement would cause economic hardship to the community, PG&E applied to the NSAPCD Hearing Board for variances.

The County's Board of Supervisors, who appoint the NSAPCD Hearing Board as well, saw no reason to irritate PG&E and jeopardize the substantial revenues the county receives from geothermal development. Hence they granted the first variance on Units 1 through 11 in 1974 for a period of four years. Subsequently, the board granted PG&E additional variances through 1980.

These actions stimulated considerable resentment in Lake County, including frequent talk of filing a lawsuit against the Sonoma Board of Supervisors. Lake County officials, who have no control over source emissions in Sonoma, also put considerable pressure on the Northern Sonoma Air Pollution Officer to find a way to force PG&E to retrofit its plants. The Northern Sonoma officer then had the unevitable task of trying to accommodate Lake's concerns and avoid being overruled by his own Hearing Board. The result was an ingenious compromise.

To avoid being overruled by the board, the Northern Sonoma officer negotiated retrofit schedules for the largest polluters (Units 3 through 6) *as a condition* for permitting the construction of Units 12, 14, and 15. The advantage of the conditional permit is that failure to meet the *conditions* is sufficient justification for the withdrawal of the permit. According to the NSAPCD, the Hearing Board does not have the power to grant variances on the conditions of the permit.

This sign of accommodation between the two county APCDs has been repeated elsewhere. For example, a four-county committee to oversee a comprehensive environmental baseline study and integrated assessment of the Geysers KGRA was recently created.¹ The committee includes one member from each county's Board of Supervisors plus representatives

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¹The four counties are Sonoma, Lake, Napa, and Mendocino.

from the California Energy Commission and ERDA. ERDA and the State Energy Commission are jointly contributing approximately \$50,000 for a planning grant, the purpose of which would be to identify research needs for a larger study of the impact of geothermal development on the area.

Accommodation also appears to be taking place on another front. During the protracted negotiations over Unit 12, PG&E continued to fight abatement.¹ At the same time, PG&E has financed several studies of air quality in the area.² In addition, the utility is testing a new copper sulfate process for H₂S abatement under a contract with ERDA.

While these steps are but the beginning of a concerted effort to develop the Geysers' geothermal resources in an environmentally acceptable manner, they signal a more cooperative climate among the principal actors involved in geothermal operations there. The costs to all sides of protracted negotiations seem to have provided incentives for accommodation.

OPPOSITION TO DEVELOPMENT IN LAKE COUNTY

The Lake-Sonoma controversy over pollution spillovers from Sonoma's plants has stimulated Lake residents to think seriously about the consequences of development for their own county. Citizens in Lake County use their knowledge of how Sonoma's plants affect what they see, smell,

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¹The Stretford scrubber process could have been installed in Unit 12. But PG&E argued that this would require the purchase of a new condenser. So the originally ordered condenser sat in a warehouse for two years while the retrofit schedule was negotiated. According to one state ARB official, it cost PG&E more to warehouse the original condenser than to buy one to accommodate the new process.

²PG&E has financed, or partially financed along with other geothermal developers, the following studies: Swanson & Mooney H₂S Survey of 1972 (at the request of the State ARB); Altshuler Air Quality Study (on-going since 1970); Unit 11 Monitoring (at the request of CPUC and NSAPCD); and the Stanford Research Institute H₂S Transport Study (at the request of LCAPCD as a condition for the granting of the Authority to Construct Unit 13). The SRI study has \$800,000 in funding from PG&E and several other developers. It is expected to last two years and to yield sufficient data on H₂S transport patterns to inform development decisionmaking in all of the lower portion of the KGRA (Tolmasoff, 1976).

and hear to judge how geothermal operations in Lake might affect their lives. Correspondingly, they also generalize from geothermal revenues generated in Sonoma to their own county's tax base. The result is an aware and divided citizenry.

Citizen Attitudes Toward Geothermal

Two citizen surveys were conducted in Lake County during 1975. On a *countywide* basis, these surveys show a population split into three groups on the question of geothermal development (Vollintine and Weres, 1976 and 1976a). One-third of those who responded to the survey were enthusiastically in favor of development. Another third favored development with strict controls. The remainder was opposed to development and distrustful of the ability of any agency to properly regulate it.

The second survey was mailed to all registered voters in the areas immediately affected by current, or prospective, geothermal development (Cobb Valley and vicinity). Opinions recorded by this survey were polarized and more intense.¹ About half of the respondents with opinions were opposed to development in any form and the other half favored controlled development.

Thus the closer Lake residents are to Sonoma's plants or to proposed development in their own county, the more negative their attitudes toward geothermal. And their feelings are not confined to mere verbal expression in surveys. Active opposition to geothermal development, particularly development proposed near scenic areas, has erupted several times over the past ten years. The intensity of this opposition has been fueled by Sonoma's past indifference to Lake County complaints and, as we document below, by the actions of Lake's own Board of Supervisors.

Active Opposition to Development

Active opposition to development in Lake County can be divided into two periods. Prior to the application of CEQA to all discretionary

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¹One measure of the intensity of feeling was the 65 percent response rate for a single-wave mail questionnaire.

acts of government in 1973, the geothermal opponent's only recourse was to try to influence the Planning Commission or the Board of Supervisors not to grant use permits. The implementation of CEQA afforded opponents more opportunities to intervene, more access to information, and a basis upon which to sue or seek injunctions.

The Mount Konocti Case. In 1965, Magma began drilling at the foot of Mt. Konocti, an extinct volcano separating the upper and lower parts of Clear Lake. One of the most prominent features of the southern lake shore, the volcano is considered sacred by the native Indians and by some of the white residents.

Controversy over Magma's drilling led to the formation of the Lake County Geothermal Control Council which protested against development at Mt. Konocti. This organization was formed by two local residents, one a Sierra Club member who later became the club's "geothermal man." But although three companies (Magma, Pacific Energy, and Getty) undertook exploratory drilling at the site, the results were negative. Drilling at this site was then abandoned, and the Lake County Geothermal Control Council died for lack of an issue.

From 1965 to 1973, drilling activity in Lake County centered around Anderson Springs, a location that is hidden from the major highway. Sporadic individual protests, but no organized opposition, arise over this activity.

The Cobb Mountain Case. In 1975, Union Oil obtained permits to drill at its Cobb Mountain leasehold. Again, a local organization--Friends of Cobb Mountain--emerged to contest Union's activity. By now CEQA applied to geothermal operations, affording environmentalists the opportunity to turn to the courts to try to stop the drilling. Pollution spillovers from Sonoma County had also raised the salience of concerns about geothermal development. In concert with the Sierra Club and the Environmental Defense Fund, Friends of Cobb Mountain filed a suit challenging the adequacy of the EIR under CEQA.

The suit claimed that a "full development EIR" (one that considers environmental impacts from the exploratory phase through the development of a power plant unit) was required, reasoning that in The Geysers, one successful exploratory well leads inevitably to a power plant. The

complainants argued that the probability of finding an exploitable resource at Cobb Mountain was high and that the initial exploration investment of \$2-3 million makes development an economic imperative for the drilling company. The suit was lost at the Superior Court level and went to the Appeals Court. When the environmental groups could not get an injunction to halt the exploration pending resolution, they dropped the suit. Because of preexisting drilling commitments, Union did not proceed with the exploration until the summer of 1976.

Mt. Konocti Revisited. In 1975 Magma again applied for a use permit for drilling on the slopes of Mt. Konocti. The company requested a negative declaration from the county on the grounds that all relevant environmental information was already available. The Sierra Club argued strongly for a full-development EIR, the county agreed, and a consulting firm was hired to prepare the document.

The first version of the EIR was described as "one of the worst" ever seen by the Planning Commission. After it was revised, the Planning Commission certified the adequacy of the EIR. However, the commission denied the use permit on the grounds that Mt. Konocti was too sensitive for development, i.e., its scenic and recreational values should not be endangered. This decision was reached after several months of public hearings during which citizen opposition to development at Mt. Konocti was vehemently expressed. At this point, however, Magma appealed the decision to the Board of Supervisors, two of whom had leased their own land for geothermal development. The Board of Supervisors subsequently overruled the Planning Commission and granted permits for two exploratory wells.

The Board's action inflamed the environmentalists and led directly to the formation of the Lake County Energy Council, an organization with a membership of 1100. The Council filed suit in Superior Court in May 1976--on the grounds that a full development EIR was required and Magma had not adequately considered the alternatives to the project. The case was lost in Superior Court, appealed, and again decided in favor of the developer in June 1977. Since the Magma venture was intended to supply power to the Sacramento River complex which Dow recently abandoned, it is unclear whether Magma intends to go ahead with the exploration. Magma has currently suspended operations in the area.

Other Activity Against Development. In late 1976, the Lake County Energy Council filed another suit against the county. Once again the issue was the adequacy of an EIR covering only the exploratory phase for a Union project at Thurston Lake, directly south of lower Clear Lake. The probability of finding an exploitable steam resource at this site is high, and the residents on the eastern side of lower Clear Lake (Clear Lake Park, Clear Lake Highlands) are concerned about both the visual and olfactory impact of a power plant constructed upwind.

From time to time another private group--the Dawn Horse Communion which purchased the area around Siegler Springs--has also involved itself in the county permit granting process. Although several of its members hold membership in the LCEC, this group is not part of the larger organization. It is more concerned with development in the immediate area of its springs rather than the county as a whole and appears to have reached a private accord with developers interested in the Siegler Springs area. Finally, private individuals have also intervened in the permitting process--usually by voicing their protests or directly seeking support from county officials.

The preceding history illustrates the importance of local organizations in spearheading active opposition to development in Lake County. While the Sierra Club was involved in early protests, local organizations have figured in each major contest. Currently the Sierra Club has withdrawn from the arena, relying on the Lake County Energy Council to continue the battle. And the Council has readily taken the lead in disseminating information to concerned citizens, developing strategies of opposition and filing court suits.

While the opposition to geothermal has not prevented any development, it has succeeded in making environmental concerns salient to Lake County citizens and officials alike. Each case of opposition to a specific proposal has reinforced the legitimacy of environmental concerns and enhanced the citizens' ability to identify and protect their interests. Each case has also demonstrated that an organizational base can be mobilized and effectively used to delay development when an issue arises.

Official Attitudes Toward Development

Despite some indifference to environmentalists in the past, local officials in Lake County are not insensitive to the problems of balancing environmental and energy tradeoffs. In fact, they are acutely aware of the critical problem of obtaining public input prior to development.

For example, even though public hearings on Negative Declarations are not required by law, the County Planning Commission usually holds public hearings and generally announces them two weeks in advance. Two years ago, the Lake County Air Pollution Control Director began organizing Geothermal Environmental Seminars which have brought together developers, federal, state, and local officials, and private individuals in the county for information exchange. In addition, the County Planning Commissioner has been directly involved in several opinion surveys conducted in the area.

The County Board of Supervisors, which has been the least sensitive to environmental groups, has recently appropriated \$10,000 from its small budget as "seed money" for developing a general Geothermal Resource Impact Planning Study (GRIPS) to provide the information needed for zoning the entire county and designating areas considered too sensitive for geothermal development.¹

FUTURE DEVELOPMENTS

While development of power-generating facilities in Lake County has been delayed, it has not been prevented. PG&E's first plant in the county is now under construction. Other entities have become interested in the geothermal potential of the lower Lake County area.

Besides Union Oil, other companies that have undertaken drilling or applied for permits include Chevron, Amin Oil (originally Signal), Phillips, Getty, Magma Power, Republic Geothermal, McCullough, Dow, and Natomas. Many of these companies also own leases. Magma, Dow, and Republic Geothermal are interested in power plant development as

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¹GRIPS has now been extended to include the four major counties in the KGRA.

well as resource development. The oil companies are generally interested only in developing and selling the steam.¹

If all development proceeds as planned, Lower Lake County could be producing 1500 megawatts of electricity by 1995. While admittedly optimistic, any development approaching such a scale will have a significant impact on land use. Before major development can proceed, however, it will be necessary to convince Lake citizens that the negative environmental impacts can be mitigated.

Proper design and siting of generating facilities in Lake County could minimize the aesthetic degradation of the Valley. In some cases, slant drilling could be used to decrease the length of above-ground steam lines. Drilling operations can be muffled and scheduled to minimize the annoyance to residents and vacationers. Hydrogen sulfide emissions can also be substantially abated. All of the mitigation techniques are currently feasible and the costs are not high enough to make exploitation of the resource uneconomical.

The hardest job faced by those in favor of geothermal development is to convince the local population that *future* development will not have the same impacts as *past* development. Increasingly, however, the localized impacts of geothermal development are being taken seriously as impediments to the kind of full-scale operations geothermal proponents would like to see. If the inputs to the GRIPS program and others like it are taken seriously, if available mitigation measures are utilized, and if people can be convinced that geothermal development will be beneficial to them (either by reducing their energy costs or by increasing revenues), development in Lake County is likely to proceed.

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¹The Northern California Power Association, an organization of a dozen municipal electrical systems, is also interested in electricity from geothermal. The members currently buy electricity from the Bureau of Reclamation's Central Valley Project and, increasingly, from PG&E. The study of its unsuccessful attempts to develop power at The Geysers is too lengthy and complex to go into here, but an excellent summary is provided in a Stanford Environmental Law Society document (Lindsey and Supton, 1975).

Appendix B
DEVELOPMENT IN THE IMPERIAL VALLEY

By Sandra Brewer

Geothermal development in the Imperial Valley is still in its infancy. Despite a history of drilling that goes back 50 years, no commercial plants producing electricity from geothermal resources have yet been constructed. An experimental 10-megawatt facility has been operating since June 1976 to test the feasibility of exploiting the geothermal resources near the Salton Sea.¹ Additional current and projected geothermal activities include a 50-megawatt demonstration plant in the Heber area, a 50-megawatt electrical power plant in East Mesa, a 10-megawatt pilot plant in East Mesa, and exploratory well drilling in North Brawley.

Imperial County consists of arid areas of the Colorado Desert coupled with verdant agricultural lands irrigated by water imported from the Colorado Desert via the All American Canal. The climate has typical desert characteristics of high temperatures, low relative humidity, and scant precipitation.

Six Known Geothermal Resource Areas (KGRAs) have been established within the Imperial Valley: Brawley, Dunes, East Mesa, Glamis, Heber, and Salton Sea. Areas are designated as KGRAs by measuring temperature gradients within the thermal anomalies. Resources with temperatures above 150 degrees centigrade are capable of generating electricity, while those below are confined to process and space heating uses. Of the six KGRAs in the Imperial Valley, four possess temperatures above 150 degrees centigrade and are also large enough to be potentially viable for commercial production: Brawley, East Mesa, Heber, and Salton Sea. The Salton Sea anomaly was the first to be investigated, and to date most of the development activity has taken place there.

This appendix presents an overview of the history of geothermal development in the Imperial Valley, examines several potential causes

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¹This facility was designed to test the energy conversion process and not to produce electricity.

for the slowness of development there, and describes citizen and official attitudes toward current and proposed activities.

HISTORY

Early attempts to develop geothermal resources in the Imperial Valley were unsuccessful but led to the discovery of a carbon dioxide field which produced dry ice from 1942 to 1954.¹ The first exploratory well to produce substantial amounts of steam and hot water was drilled in 1957 at Niland (12 miles south of the Salton Sea), but the plant constructed to utilize this steam was forced to shut down because excessive scaling from the highly saline and corrosive brines precluded a successful commercial operation.

In the early 1960s, several additional wells drilled in the vicinity of the Salton Sea produced steam from very hot water reservoirs (207 degrees centigrade). Brine analyses showed exceedingly high mineral contents, some of the brines possessing concentrations of more than 300,000 parts per million total dissolved solids. The salinity again resulted in corrosion and scaling problems. The 30 percent mineral content of the brines led to an attempt to extract and sell the mineral by-products.² This project was discontinued because the cost of maintaining the installation (due to the highly corrosive nature of the brines), coupled with a decline in the world price of the minerals extracted, made it uneconomical.

Investigations over the next decade extended the area of known geothermal resources and resulted in the designation of areas outside the Salton Sea anomaly (Dunes, East Mesa, Heber, and North Brawley). Prior to 1971, 28 exploratory wells had been drilled in the Imperial Valley.

The pace of activity quickened in the 1970s. Between 1971 and 1975, 33 new wells were drilled in the known resource areas by major oil companies and independent exploration companies and investors.

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¹Three exploratory geothermal wells were drilled in 1927 but were subsequently abandoned for lack of pressure and water volume.

²Primary efforts were devoted to recovery of potash from the brines.

Primarily involved were Chevron Oil Company, Magma Power Company, Imperial Magma, the U.S. Bureau of Reclamation, Union Oil Company of California, and Republic Geothermal, Inc.

To test the feasibility of using different materials and engineering schemes to exploit the geothermal fluids in the Salton Sea KGRA,¹ San Diego Gas and Electric Company (SDG&E) and Imperial Magma constructed an experimental 10-megawatt facility near Niland which began operating in June 1976.² This prototype closed-system plant is designed to utilize transferred heat from the hot waters of the Salton Sea anomaly for power generation. Due to the high salinity of the brines in this area (five to eight times that of sea water), problems of corrosion and scaling of the equipment have been encountered. Until these problems are overcome, using the Salton Sea anomaly for reliable generation of electricity cannot be accurately predicted.³

SLOWNESS OF DEVELOPMENT

Development of the geothermal resource in the Imperial Valley has been retarded by technical and economic uncertainties. The anomalies consist of liquid dominated, high to moderate temperature, highly saline brines. Technical uncertainties are involved in the exploitation of the hot saline brines, which are corrosive. Other problems center around proving reservoir capability in the various anomalies, demonstrating wet reservoir conversion machinery, and developing adequate cooling water sources. Until these uncertainties are resolved, an accurate prediction of economic feasibility cannot be determined.

Marked differences in dissolved mineral content of the geothermal fluids have been observed between the Salton Sea KGRA and the anomalies in the southernmost areas of the Salton Trough. The latter, while not as hot as the Salton Sea anomaly, are substantially less saline. This would suggest that conditions are more favorable for geothermal power

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¹The largest in the region (95,824 acres, 50 percent of which underlies the Salton Sea), this KGRA possesses the hottest fluids.

²The plant design is actually a hybrid combination of the flashed steam and binary systems.

³Optimistic estimates for the capability of power generation from this anomaly are 50 to 75 megawatts by the end of 1981.

production in the Brawley, East Mesa, and Heber anomalies than in the Salton Sea KGRA which has thus far been the most extensively developed.

COUNTY ATTITUDES TOWARD GEOTHERMAL DEVELOPMENT

Imperial County officials are generally enthusiastic about the development of the county's geothermal energy resources, and public opposition to geothermal development has been negligible and short-lived.

Past Sources of Opposition

In 1975, an individual citizen filed a formal appeal to protest the Imperial County Planning Commission's issuance of three geothermal exploratory well permits to Chevron Oil Company for drilling in the Heber anomaly. His contention was that geothermal developers were not adhering to CEQA guidelines. His appeal was ruled invalid because he did not reside within the appeal area (within one and one-half miles of the proposed drilling sites), but the County Board of Supervisors promised to review the safeguards then being applied to geothermal well drilling permits. In addition, his protest provoked a major developer, on behalf of his own and four other companies, to visit the citizen and write him a letter explaining the company's policy.

In June 1976, a woman representing a small, one-issue environmental organization (now apparently defunct) appeared at a Water Quality Control Board meeting to protest the issuance of a waste discharge permit. She contended that geothermal brines were going to be deposited into the Salton Sea. The charge was based on a provision in a waste discharge permit issued to SDG&E stating that the developer proposed to discharge an average of 200,000 gallons-per-operating-day of cooling pond blowdown water into Vail Drain 4A, subsequently flowing into the Salton Sea. The Board explained that its standards prohibited spent geothermal brines from being deposited either into the Salton Sea or into the surface water. The cooling pond blowdown consisted of water originally procured from the Imperial Irrigation District and did not contain brines. This organization has not been heard from since that meeting, and a thorough search failed to locate the single known member of the group.

A group of residents and commercial property owners near the Salton Sea formed the Project Salton Sea Committee six years ago to preserve the Sea's recreational aspects and viability as a tourist attraction. The group meets regularly but has not yet articulated any formal objections to geothermal development.

To date, citizen opposition has consisted of sporadic, individual protests rather than an organized, collective effort. However, the flurry of activity responding to these two protests indicates that public officials and private developers are sensitive to citizen concerns about development.

Lack of opposition can be related to the stage of development of an energy resource. Since Imperial Valley residents have not experienced large-scale geothermal activities, there has been minimal concern about undesirable effects. This lack of opposition, however, should not be viewed as an indication that no opposition will develop if the resource becomes commercial.

Potential Sources of Opposition

Agriculture is and most likely will remain the Valley's prime economic base.¹ Should opposition to geothermal development surface in the Valley, it will most likely be in connection with agriculture. Productive agricultural lands overlie many of the geothermal reservoirs in the Imperial Valley, and policies must be developed to allow coexistence of both activities. To minimize impacts on agricultural activities, county officials want transmission line locations, well and plant siting, and construction of access roads to be considered in planning for geothermal development.

Environmental impacts that could trigger opposition include disturbance of the agricultural irrigation and drainage canal system, conflicts over scarce water supplies, or pollution of the water.

Although the flat dry lands of the Imperial Valley are not considered scenic enough for land degradation to have much impact, land subsidence or induced seismicity could seriously disrupt the irrigation

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¹The local economy centers around agriculture, with over a half million acres under cultivation producing a gross value of \$550,000,000.

and drainage canals on which the Valley's agricultural economy depends. These problems are more likely to occur in the Valley than in The Geysers because a greater volume of hot brine resources must be withdrawn to produce amounts of electricity equivalent to that produced from a vapor system.

Many geothermal sites in the Valley are adjacent to extensively irrigated farmlands which get their water supply from the over-appropriated Colorado River. Conflicts over the scarce water supply could threaten agricultural production and thus the county's main source of revenue. In addition, surface water pollution could become a problem if reinjection of the waste brines is not feasible on a large scale. However, unless geothermal development threatens agriculture (through damage to the agricultural drainage tile system or the crops), the local citizenry is unlikely to oppose it.¹

OFFICIAL ATTITUDES TOWARD DEVELOPMENT

Responses from certain state and federal agencies--in particular, the California Department of Fish and Game and U.S. Fish and Wildlife--have indicated a concern that while geothermal is generally regarded as a benign energy source, issues of impacts on surface land resources must be addressed. These agencies advocate advance planning and an environmental assessment of an entire region prior to the test well phase of geothermal development.²

Other agencies, such as the Air Resources Board and Water Resources Control Board, strongly favor geothermal development and feel that any

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¹ Areas of desert overlie the Dunes and Glamis KGRAs. Because of their small resource potential, however, these anomalies are not likely to be developed. The Salton Sea, California's largest inland water body, has in the past been utilized as a fishery and for recreational activities. Present concerns center around its increasing salinity (due to runoff from agricultural leaching) and rising boundaries. If cooling water for geothermal operations is taken from the Sea, the sea-level would be lowered but the salinity increased.

² They have also criticized certain environmental assessments in the past as being inadequate (e.g., one "project plan" totally ignored the proximity of a geothermal development site to the nesting area of the Yuma clapper rail).

environmental concerns can be alleviated through abatement and regulatory procedures.

County actions thus far have usually facilitated development. For example, securing permits and certifying environmental assessments generally take less time in the Imperial Valley than at The Geysers. The cost of obtaining permits and environmental data is also lower.

This positive approach is also illustrated by early county policies toward geothermal development. In 1971, the County Department of Public Works set forth basic guidelines that would allow various public and private agencies to initiate geothermal development projects but that would also prevent rampant misuse of the land (Imperial County, 1971). This interim policy called for the development of a General Plan for the total development of the county's geothermal resource. The Imperial County Goals published in 1975 included a commitment to preserve the county's basic agricultural economy while stimulating development of geothermal energy.

In December 1976, the county issued a revised version of its policies regarding geothermal development.¹ This version, which reiterated the policy established by the County Board of Supervisors in 1971, stated, "Be it resolved that a general plan shall be prepared to designate where and under what conditions geothermal production wells, power plants and intended uses may be located in Imperial County." The general plan, now being formally adopted, is designed to afford a broad base of resource data regarding issues involved in developing the geothermal resource in the Imperial Valley. In addition, county officials anticipate that information contained in the Geothermal Element to the County's General Plan can be used by other areas faced with major development.

CONCLUSIONS

The Imperial Valley is a potentially productive area for geothermal energy utilization. Commercialization of the resource has not yet been realized, and there are ongoing technological uncertainties in

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¹"Issues, Goals, Objectives and Policies," draft prepared by Planning Department of Imperial County, 1976.

exploiting the hot brines. As geothermal activity increases in the Valley, the regulatory process is likely to be revised and may result in greater delays than those presently being experienced.

While there is lack of opposition at present, any threat to the county's main source of revenue or lifestyle would most likely produce substantial resistance. Nevertheless, a climate exists for responding to citizen concerns, and Imperial County could avoid the antagonism between pro- and anti-development groups which has characterized Lake County's past development.¹

County officials, cognizant of the potential for impacts on both the economy and the environment, have enthusiastically supported the work of the Imperial Valley Environmental Project (IVEP). This study may reduce many of the present uncertainties about the compatibility of geothermal development with the local environment. Parallel to the IVEP, the Geothermal Element to the County's General Plan is an effort to control environmental impacts while allowing ongoing development.

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¹Examples of this positive climate include the response of both the county and developers to an individual citizen's protest as well as the county's emphasis on planning for development.

Appendix C

PROJECTED COSTS OF GEOTHERMAL DEVELOPMENT:
VAPOR AND LIQUID DOMINATED SYSTEMS

Table C.1

GEOTHERMAL CAPITAL COSTS FOR VAPOR DOMINATED SYSTEMS
(1976 \$)

Source	Year	Capacity (Mw)	Expected Field Investment (\$/kw)	Plant Investment (\$/kw)	Total Investment (\$/kw)
Armstead	1973	200	105	177	282
Worthington	1974				
Geysers:					
Units 1 & 2	1960	24	-	308	-
Units 3 & 4	1967/68	54	-	229	-
Units 5 & 6	1971	106	-	167	-
Units 7 & 8	1972	106	-	138	-
Units 9 & 10	1973	106	-	162	-
Unit 11	1975	106	-	143	-
Unit 12 ^a	1978	106	-	135	-
Unit 14 ^a	1978	110	-	144	-
Unit 15 ^a	1978	110	-	198	-
Unit 13 ^a	1979	135	-	148	-
Grieder	1976a				
Geysers:					
Units 1-11		502	98	-	-
Units 12-15 ^a		406	110	-	-
New steam systems		200	156	221	377
Krumland	1976				
Geysers					
Units 9 & 10	1973	106	-	176	-
Unit 11	1975	106	-	170	-
Unit 14 ^a	1978	110	-	259	-
Unit 15 ^a	1978	55	-	319	-
Unit 13 ^a	1979	135	-	217	-
Ramachandran	1977a,b	-	-	250-280	-

^aCurrently under construction.

Table C.2

DISTRIBUTION OF COSTS FOR VAPOR DOMINATED SYSTEMS
(1976 \$: mills/kw-hr)

Source	Year	Capacity (Mw)	Energy Charges	Plant		Costs of Power
				Capital Charges	O&M	
Grieder	1976a					
Geysers:						
Unit 15 ^a		55	7.8 ^b	3.3 ^c	-	11.1
Unit 13		135	7.8	5.7	-	13.5
New steam systems		200	-	-	-	10.5-13.7
California Public Utilities Comm.	1975					
Geysers:						
Unit 12 ^d		106	7.8 ^c	3.37 ^b	-	11.17
Unit 14		110	7.8	4.14	-	11.94
Unit 15		55	7.8	3.45	-	11.25
Unit 13		135	7.8	5.1	-	12.9
Edmunds	1976	-	-	-	-	15-22
Krumland	1976					
Geysers:						
Unit 14		110				
90% load factor			13.5	6.7	.5	20.67
80% load factor			13.5	7.5	.55	21.53
70% load factor			13.5	8.5	.6	22.64
Ramachandran	1977					
Geysers:	a,b					
Unit 11		110	13.0	4.0	.6	17.6
New Units		-	13-15	6.8	.6	20.4-22.4

^a80% load factor. The average load factor at The Geysers from 1961-1974 was 75.6 (Matthew, 1975).

^b1975 contract price adjusted. 1977 contract steam price is 13.0 mills/kw-hr including reinjection.

^cFixed charges and other operation and maintenance expenses.

^d90% load factor.

Table C.3

GEOTHERMAL CAPITAL COSTS FOR LIQUID DOMINATED SYSTEMS
(1976 \$)

Source	Year	Capacity (Mw)	Type	Expected Field Investment (\$/kw)	Plant Investment (\$/kw)	Total Investment (\$/kw)
Holt & Brugman	1974	50	<i>Binary:</i> 400° F Reservoir 500° F Reservoir	- -	356 287	- -
Grieder	1976a	200	<i>Binary: (Imperial Valley)</i> 400° F Reservoir 500° F Reservoir <i>Flash:</i> 500° F Reservoir	166 - 165	510 431 412	676 - 577
Dart et al.	1975	50	<i>Binary:</i> 300° F Reservoir	557	673	1230
Bloomster & Knutsen	1976	55	<i>Binary:</i> 482° F Reservoir 392° F Reservoir 302° F Reservoir <i>Flash:</i> 482° F Reservoir	126 217 848 117	378 385 431 334	494 602 1279 452
Holt (from Larson)	1976	50	<i>Flash & Binary</i>	200-300	450-550	650-850
Edmunds ^a	1976/77		<i>Flash & Binary (Imperial Valley)</i>	200-250	300-500	500-750
Hankin	1976	50	<i>Binary</i> Heber - 300° F	-	782	-
Bechtel	1976	50	<i>Flash</i> Heber - 300° F <i>Hybrid</i> Niland - 550° F	- - -	782 780	- -
Goldsmith	1976		Imperial Valley 300° F Reservoir 480° F Reservoir	300-400 150-200	- -	- -

Table C.3 (cont'd)

Source	Year	Capacity (Mw)	Type	Expect'd Field Invest't	Plant Investment	Total Investment
Holt/Procon	1976		<i>Binary:</i>			
			Heber - 300° F	236	570	806
			Valles Caldera-500°F	336	530	866
			Raft River - 300° F	590	646	1236
			<i>Flash:</i>			
			Heber - 360° F	287	536	823
			Valles Caldera-500°F	428	562	990
			Raft River - 300° F	846	718	1564
			<i>Hybrid:</i>			
			Heber - 360°F	244	732	976
Larson ^b	1977	200	<i>Flash/Binary:</i> (Imperial Valley)			
			Optimistic case	172	200	472
			Pessimistic case	300	500	800
			Alt. pessimistic case		800	1100
Ramachandran	1977a,b		Hot water		530-800	

^aEdmunds (1977) indicates that some industry sources feel that costs may run as high as \$100/kw installed capacity.

^bLarson indicates a possibility that his figures may still be too low and that plant investment in the Imperial Valley may be up to \$1000/kw (personal communication).

Table C.4

DISTRIBUTION OF COSTS FOR LIQUID DOMINATED SYSTEMS
(1976 \$: mills/kw-hr)

Source	Year	Capacity (Mw)	Type	Field		Energy Charges	Plant		Cost of Power
				Return on Capital	O&M		Capital Charges	O&M	
Grieder	1976a	55-110	<i>Binary:</i> 400° F Reservoir	-	-	8.6	10.9	1.5	16.8-21.0
			<i>Flash:</i> 500° F Reservoir	-	-				10.5-18.9
Bloomster & Knutsen	1976	55	<i>Binary:</i> 482° F Reservoir	-	-				22.4
			392° F Reservoir	16.2	6.4	22.6	9.4	.46	32.4
			302° F Reservoir	60.1	26.9	87.0	10.6	.8	98.0
			<i>Flash:</i> 482° F Reservoir	7.7	3.6	11.3	8.2	.3	19.8
Holt/Procon	1976		<i>Binary:</i> Heber	-	-	16.69	15.03	3.22	34.94
			Valles Caldera	-	-	16.03	13.72	2.91	32.66
			Raft River	-	-	32.80	16.83	3.57	53.2
			<i>Flash:</i> Heber	-	-	20.53	14.13	3.14	37.8
			Valles Caldera	-	-	20.65	14.53	3.33	38.51
			Raft River	-	-	46.61	18.70	3.07	68.98
			<i>Hybrid:</i> Heber	-	-	17.26	19.30	3.65	40.21
			Valles Caldera	-	-	18.99	19.45	3.52	41.96
			Raft River	-	-	42.42	20.73	3.94	67.09

Table C.4 (cont'd)

Source	Year	Capacity (Mw)	Type	Field		Energy Charges	Plant		Cost of Power
				Return on Capital	O&M		Capital Charges	O&M	
Edmunds	1977	-	-	-	-	-	-	-	30-35
Larson	1977	50	<i>Flash/Binary:</i> (Imperial Valley)	-	-	-	-	-	-
			San Diego Gas & Electric (Heber)	-	-	-	-	6.94	-
			Union Oil	-	3	-	-	-	-
			Grieder	-	5.7-6.4	-	-	-	-
			Holt	-	3-6	-	-	-	-
		200	Optimistic case	9.8	3	12.8	4.2	1.5	18.5
			Pessimistic case	13.3	6	19.3	13.2	3	35.5
			Alt. pessimistic case	-	5-7.5	-	-	6-9	-
Ramachandran	1977a,b		Hot water	-	-	-	-	-	37-72

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