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A PROGRAM PLANNER'S GUIDE TO GEOTHERMAL DEVELOPMENT IN CALIFORNIA

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ENERGY & ENVIRONMENT DIVISION

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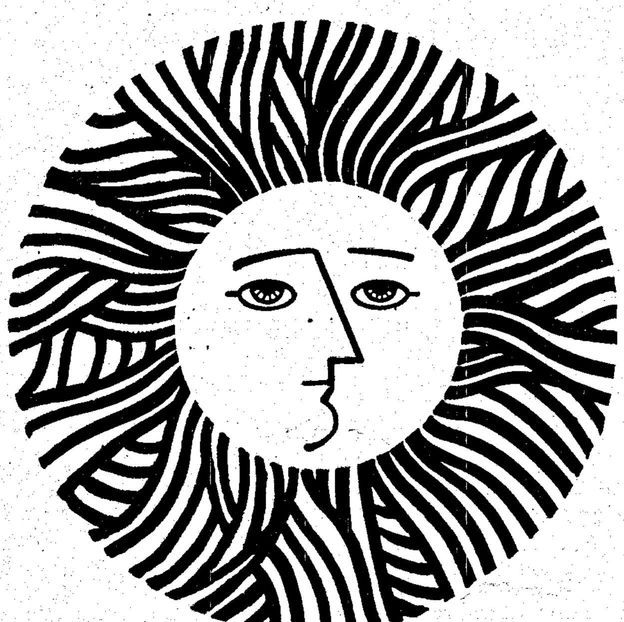

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A PROGRAM PLANNER'S GUIDE TO GEOTHERMAL DEVELOPMENT IN CALIFORNIA

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September 30, 1980

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For the Office of the Regional Representative, Region IX, and the
Geothermal Energy Division, San Francisco Field Operations Office
Office of Renewable Resources
Assistant Secretary for Resources Applications

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EXECUTIVE SUMMARY

ROLE OF GEOTHERMAL ENERGY IN CALIFORNIA

Geothermal energy can reduce dependence on fossil fuel and nuclear energy in California by meeting fuel requirements for baseload electric power and process heat in the residential, commercial, and industrial sectors.

It can assist in the economic development of sparsely populated communities in remote areas by providing a reliable and inexpensive source of energy.

BACKGROUND

Resource Base

Geothermal resources consist of pockets of heat in the earth which can be exploited economically to fill energy demands. The U.S. Geological Survey has identified significant hydrothermal reserves in California. These include both dry steam and hot water systems in the range of 90°-350°C. The recoverable thermal energy of medium- and high-temperature resources is estimated to be the equivalent of 11,300 MWe of power for 30 years.

Development of geothermal resources for electric power production and direct heat applications is a site-specific process. The temperature, flow rate, depth, and field chemistry of each geothermal system is unique; and technical, economic, environmental, and institutional factors which influence the success of development may differ at various sites.

History of Geothermal Development in California

Electric power production at The Geysers began in 1960 with a 12 MWe generating plant. Today, The Geysers region is the largest producer of geothermal electric power in the world, with 908 MWe of generating capacity.

Electricity production from geothermal resources is projected to reach 3,364 MWe by 1990. This will include a total of 960 MWe from the hot water systems in the Imperial Valley, and 2,404 MWe from The Geysers dry steam reservoir. Current capital costs are between $450-$500/KW for dry steam electric power plants, $600-$950/KW for flash systems, and about $1,100/KW for binary systems. Total energy costs are between 20-30 mills/KWh for dry steam power plants, and about 56-60 mills/KWh and 65 mills/KWh, respectively, for flash and binary systems coming on line in 1985.

Present uses of low and moderate temperature geothermal waters include spas, fish and prawn farming, and green-house operations. About twenty new projects, including space conditioning, feedstock operations, and food processing are being evaluated with support from both the state and federal governments.

KEY FINDINGS

- The political and industrial climate for geothermal development in California is very favorable.

  - Geothermal has been assigned an important role in California's aggressive Alternative Energy and Transportation Program. The state Department of Water Resources (DWR) is using its position as a major producer and consumer of energy to pursue geothermal production at five sites around the state. Inventories are underway to identify potential direct heat projects at state facilities. (Sections 4.22, 5.23, 7.3)

  - The federal government has funded significant research to identify and define geothermal resources in California and to assist in the development of the resource. (Section 5.1)

  - There is substantial industry activity at promising geothermal areas. Commitment to geothermal electricity has come from both larger (PG&E, SCE, SDG&E) and smaller (SMUD, DWR, NCPA) utilities (Sections 2, 4.2, 6)

- State agencies have organized to foster geothermal development by streamlining the regulatory process and providing assistance to local communities.

- A two-fold transfer of technical expertise and authority from the state to local communities is taking place through collection of environmental baseline data, support for local planning, and delegation of siting or environmental review authority to counties with approved geothermal elements. Consolidated federal-state-local environmental studies are effective in rationalizing the process for completion of baseline environmental assessments on public lands. (Sections 5.14, 5.21, 5.23, 5.24)

- A significant portion of low/moderate temperature resources are located in areas away from load centers and populated areas, e.g., Lassen and Mono-Long Valley. Development of these resources for direct uses will alleviate the impact of increasing fuel costs on these communities and contribute to their economic development. Government-assisted engineering and economic feasibility studies for space conditioning, food processing, and industrial processing have attracted the interest of both resource developers and communities. (Sections 2.2, 4.3, 5.24)

KEY ISSUES

The major issues affecting the rate of geothermal development are:

- Community acceptance of geothermal development

  Future development at The Geysers and the Imperial Valley will be influenced by the local communities' perceptions and assessments of the benefits and costs of development. Local issues include land use impacts, such as siting of drilling pads, power plants, and transmission lines; the need for new services; and the cumulative effect of development on the communities' quality of life. (Sections 4.22, 5.23, 5.24)

- Access to federal land for exploration

  Key geothermal resource areas in California are managed by both federal and state agencies. Resources assessment and leasing activities at these sites have been delayed by the need to complete environmental baseline assessments and recreational use plans. A proposed solution would permit surface exploration activities (exclusive of drilling activities) concurrent with mandated activities. (Sections 2, 5.24)

- H_2S control technology

  A number of H_2S abatement technologies being tested at The Geysers (iron catalyst, Stretford process) have had the adverse effects of lowering the capacity factor or causing problems with cooling towers, or both. Since H_2S emissions are a major concern for area residents, further development of control technologies is needed to keep development in The Geysers region on schedule. (Section 4.2).

- Economic feasibility of power production from saline hot water systems

  While technological development of conversion systems (binary/flash) for saline hot water resources has been completed, the costs of power production and system reliability have yet to be demonstrated. Pilot plants scheduled to come on line during 1980-1981 will provide additional data. (Sections 2.2, 4.2, 5.1)

- o Public awareness of potential for direct-heat applications.

  Significant potential markets for direct application of low/moderate temperature resources exist in a number of California counties. For high-to-moderate temperature resources, the strategy followed at a number of sites is to consider cascading operations and cogeneration. However, the lack of public awareness about the use of geothermal heat is still a limiting factor. Workshops to inform selected industries and municipalities about geothermal direct-heat applications are needed to encourage development at sites with identified resource potential.

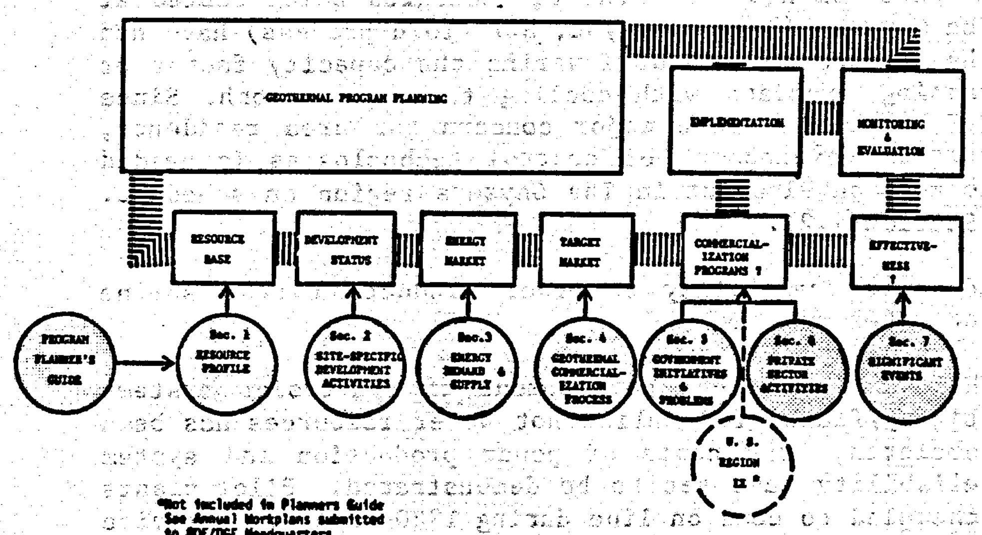
OBJECTIVE OF THE PROGRAM PLANNER'S GUIDE

This report is prepared as a reference on geothermal development in California for program and project managers in the federal and state government. It is also designed to serve as a planning tool for the State Geothermal Resource and Commercialization Teams in the development, implementation, and evaluation of geothermal programs.

METHODOLOGY

The conceptual design of the Planner's Guide is presented in Figure A.

Figure A. Conceptual Design of the Program Planner's Guide



Information included in the Guide is keyed to major technical, economic, environmental, and institutional issues at specific sites. These issues are regarded as potential barriers to development and are grouped by resource areas so that individual programs can be examined in the context of the multiple factors which influence the success of development. Interested managers can use relevant issue clusters to design, evaluate, or monitor commercialization activities or to generate new insights about the appropriate role of government-sponsored programs. Each section of the guide is self-contained. Thus, if a reader is well informed about the topic of any section or subsection, it may be bypassed. Relevant electric power and direct-use projects as well as federal, state, local and private sector programs have been summarized to illustrate the interaction of various activities. Appendices to the guide are intended to provide a ready reference of financial incentives under the Federal Energy Act, state legislation relevant to geothermal development, organizations and persons involved in geothermal commercialization efforts, and ongoing research programs.

GUIDE TO THE REPORT

Section 1. Resources Profile.

This section describes California's geology and the results of USGS resources assessments. The extent and location of geothermal reserves (identified useful resources) are shown in Figure B. Hydrothermal resources have been given the most attention because the technology is available for electricity generation for both high and moderate temperature resources. The application of low/moderate temperature resources to agriculture, aquaculture, industrial process heat, and space conditioning has also been demonstrated.

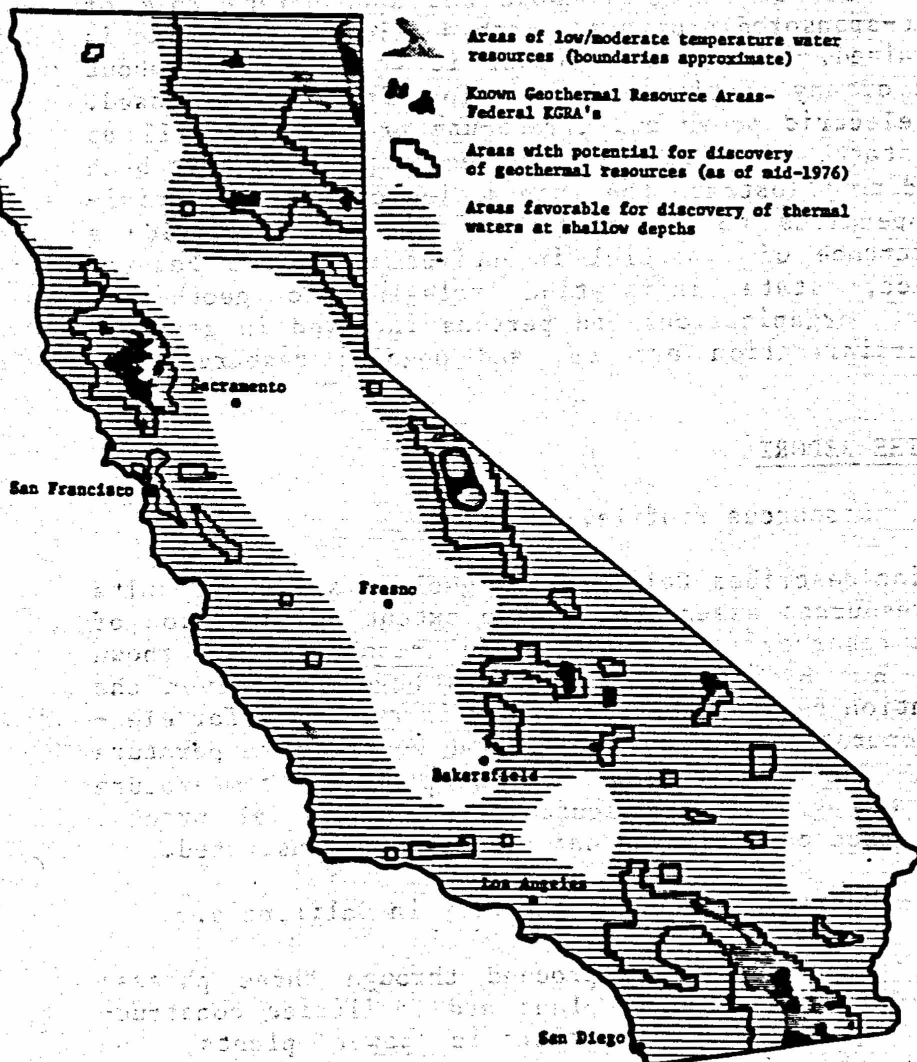
Section 2. Current Geothermal Activity in California.

Geothermal projects usually proceed through three phases: resources definition, power plant and facilities construction, and operation. For electric power plants, the development time frame is approximately 9-11 years. For direct applications, it can be as short as 2-4 years.

First generation development of a geothermal field usually begins with applications designed to establish technical and economic feasibility for power production or direct applications, or both. Expansion of production to the entire reservoir may follow when there is a market for the resource. The second generation of development begins with additional exploration to define new reservoirs in the resource area.

Section 2.1 describes resources assessment and definition activities. Leasing activities on public lands are inhibited by the number of environmental assessments required by federal and state land use policies. The future

Figure B. Location of California's Hydrothermal Resources



Source: California Division of Mines and Geology 1980, and National Geophysical and Solar-Terrestrial Data Center, 1977.

availability of federal and state land depends on environmental assessments and on conditions of the leasehold.

Significant geothermal development activities are discussed in Section 2.2 and the status of individual electric power and direct-use projects are summarized. Most geothermal electric development activity to date has centered on steam reservoirs around The Geysers; the engineering and economic feasibility of electric power production from these resources are established. The development of liquid-dominated resources has begun in the Imperial Valley. Pilot plants coming on line in the 1980's will prove the feasibility of power generation from saline hot water resources.

Direct applications to date are limited to small greenhouses, fish farming, and tourist operations. Section 2.22 presents a tabulation of commercial spas and 20 direct-use projects sponsored by DOE.

Section 3. California Energy Demand and Supply Profile

Slow growth in energy consumption reflects increasing emphasis on energy efficiency by consumers and regulators. However, in the near term (1980-1990), new energy supplies will be required even if there is vigorous conservation.

Geothermal energy can provide baseload electric power. It can also reduce economic dependence on fossil fuel by meeting some current requirements for space conditioning and industrial and agricultural process heat. This may also affect electricity consumption by satisfying demands currently met by electricity.

Section 3.2 summarizes various projections of electrical energy demand and supply patterns. The forecasts of energy demand vary widely in the scenarios developed by CEC. The absolute contribution to the electric power supply mix from geothermal resources during the periods 1980-1985 and 1985-1990 is in the ranges of 1,700-2,100 MWe and 1,700-3,600 MWe, respectively, for all scenarios.

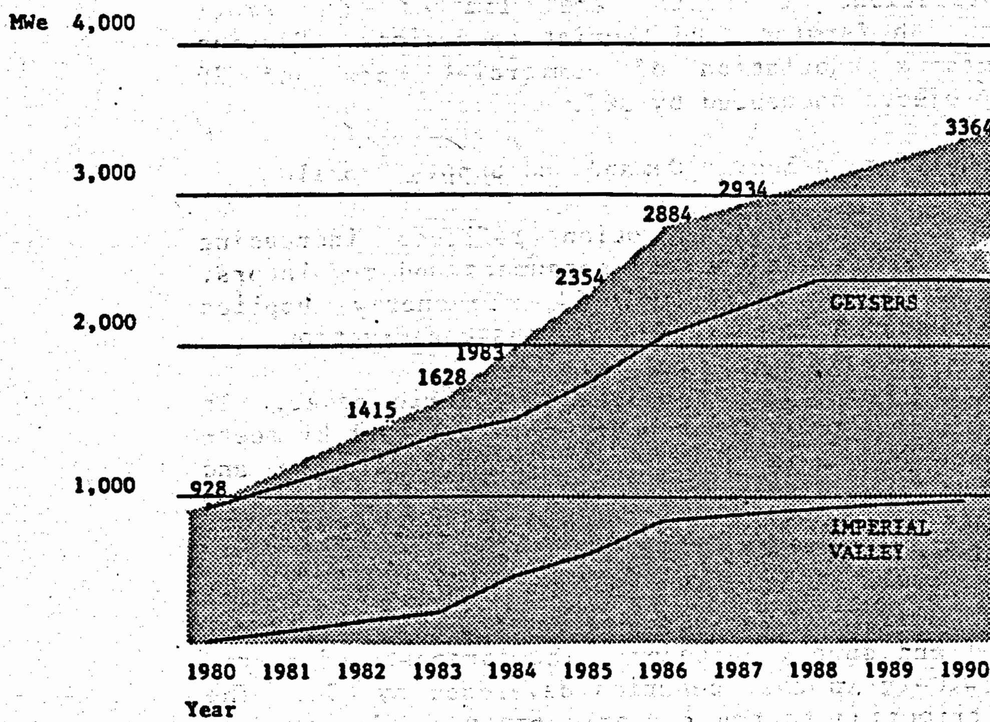
Section 3.3 reviews industrial energy use in California. Food processing is one industry with relatively large energy requirements in the temperature range of 212°F. The potential market for residential and space heating may be limited for resources located in sparsely populated areas.

Section 4. Geothermal Share of the California Energy Market

The ability of geothermal development to meet state and national goals will be governed by how quickly geothermal developers, utilities, regulators, and the public can resolve perceived uncertainties and risks associated with geothermal development. Each resource area in California is characterized by a unique set of issues.

Section 4.1 summarizes the present and projected share of geothermal electric in California. Figure C shows the projected level of geothermal capacity in California to the year 1990. The technical, economic, environmental, and institutional uncertainties perceived by major participants are described.

Figure C. Projected Geothermal Electric Capacity



Source: California Energy Commission, Geothermal Energy Updates, March 5, 1980.

Site-specific issues are discussed in Section 4.2. Figure D shows the cluster of identified technical, economic, and institutional issues at selected sites. Information on resource areas outside The Geysers and the Imperial Valley is limited because development at these sites are still at an early stage. Operating experience at The Geysers dry steam reservoir can be applied only selectively to the prospective development of hot water resources elsewhere in the state because resource, techological, and economic attributes of each geothermal reservoir vary substantially. However, institutional innovations by county and state agencies to promote planning and information dissemination in The Geysers region might be transferable.

Section 4.3 discusses the different patterns of entry into the direct-use market. They include location-based operations (e.g., spas, greenhouses), formally analyzed operations that match an application to a suitable resource, and government-aided operations (supporting diverse first-on-

Figure D. Geothermal Development Issues at Various Selected Geothermal Resource Areas

		THE GEYSERS	IMPERIAL VALLEY	GLASS MOUNTAIN	SURPRISE VALLEY	MONO/LONG VALLEY	COSO
TECHNOLOGICAL ISSUES	Resource Definition	Mid-term	Short-term			Mid-term	Mid-term
	Hot Water Technology	Long-term	Short-term				
	H_2S Abatement	Short-term	Mid-term				
	Scaling		Short-term				
	Seismicity		Short-term				
	Subsidence		Mid-term				
ECONOMIC ISSUES	Market			Mid-term	Mid-term	Mid-term	
	Cost of Power		Short-term				
	BLM Lease Re-evaluation	Mid-term	Mid-term				
ENVIRONMENTAL ISSUES	H_2S Abatement	Short-term	Short-term				
	Well-Pad Siting	Short-term					
	Solid Waste Disposal	Long-term	Short-term				
INSTITUTIONAL ISSUES	County Planning	Short-term	Short-term				
	Transmission Lines	Short-term					
	Cooling/Injection Water		Short-term				
	Federal/State Leasing			Mid-term	Mid-term		

Short-term: Affects current development

Mid-term: Affects full-field development

Long-term: Affects development of new reservoirs in area

Source: See References, Section 4.22.

site applications). The potential for location of various direct-use applications is highlighted by county.

Section 5. Government-Supported Activities and Initiatives.

The roles and policy instruments available to each level of government differ, yet they are interrelated aspects of the effort to commercialize geothermal energy. While the risks and benefits must be calculated at each project and site, government initiatives can be designed to reduce uncertainties or insure risks, or to increase the potential benefit of successful developments. State and federal agencies can also support the acceptance of geothermal development by transferring planning and evaluation capabilities to local bodies.

The goals and objectives, strategy, and management approach of federal geothermal commercialization programs are presented in Section 5.1. Individual DOE programs for research, development and demonstration, and information dissemination are summarized in Sections 5.11-5.14. A significant issue in the development of state geothermal policy is the need for local government to take an active role in the management of geothermal development. Section 5.2 describes the development of existing state and local programs.

Section 6. Private Sector Activities and Initiatives.

Government-sponsored commercialization initiatives must complement the development of private sector institutions and initiatives. The utility of government activities to industry participants provides important feedback to commercialization planners.

Section 6.1 summarizes the current and projected level of investments in leasing, drilling, and development activities at various sites in California. Section 6.2 examines a number of geothermal project financing mechanisms, such as reservoir insurance, leverage leasing, and interim risk-assuming companies. Section 6.3 reviews the programs of the Geothermal Resources Council and the Electric Power Research Institute to foster infrastructure development within the industry. Industry responses to government initiatives and programs are highlighted in Section 6.4.

Section 7. Significant developments.

Acceleration of geothermal development through active removal of barriers offers both opportunities for innovation and opportunities for conflict. Government program planners must be informed of changes which will affect the outcome of site-specific developments. The National Progress Monitor System (NPMS) was created in FY 79-80 to meet the continuing information needs of the federal geothermal program. In addition, a number of documents published by state and private organizations provide periodic updates of institutional developments at the regional and local level. Significant events reported in the Geothermal Progress Monitor (Department of Energy), Geothermal Energy Updates (California Energy Commission), and the Geothermal Hot-Line (California Department of Conservation) are included in Section 7.1 (Exploration and Leasing Activities), 7.2 (Electric

Power Plants and Direct Heat Applications), 7.3 (Federal/State/Local Programs), and 7.4 (Industry Activities).

Appendix I. Financial Incentives Provided Under the National Energy Act.

Appendix II. Summary of California Legislation Relevant to Geothermal Development.

Appendix III. Organizations/Officials Involved in California Geothermal Commercializaton.

Appendix IV. Geothermal Research Programs in California.

ACKNOWLEDGEMENTS

This work is supported by the Assistant Secretary for Resources Applications, Office of Renewable Resources, Geothermal Energy Division, San Francisco Field Operations Office and the Office of the Regional Representative, Region IX under contract W-7405-ENG-48.

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INTRODUCTION

Geothermal energy is assuming an important role in California's energy market. Changes in the technical, economic, and institutional environment for energy resources development have encouraged efforts by both the private and public sectors to expand the number of geothermal applications. As the number of commercial sites and actors increase, development issues and proposed solutions have become more complex. The implications of this for implementation of geothermal programs is that program planners and managers must be prepared to respond to a multiplicity of issues, actors, and institutions.

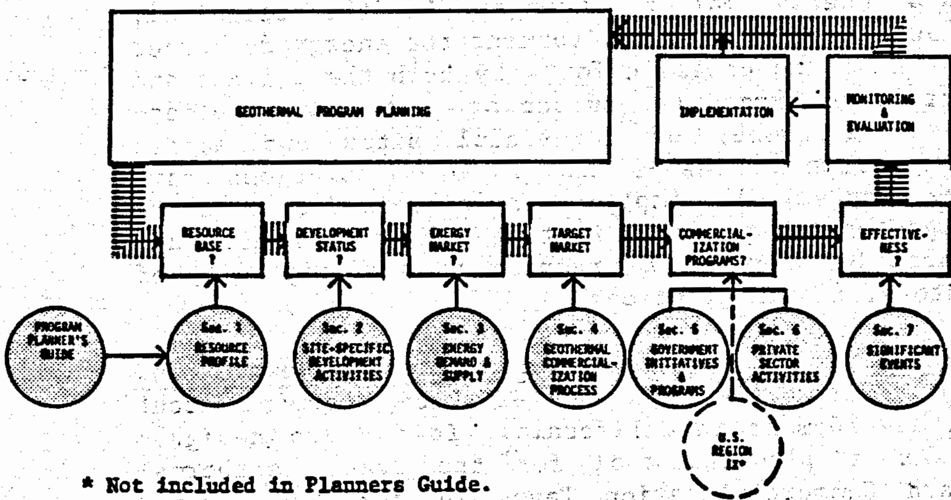
The Program Planner's Guide to Geothermal Development in California is prepared as a reference document about geothermal development in California. It is also designed to serve as a planning tool for the State Geothermal Resource and Commercialization Teams in the development, implementation, and evaluation of geothermal programs.

A basic assumption of the report is that commercialization of geothermal energy is a site-specific process. Unique resource, market, and environmental considerations at each location influence the pace of development and its relationship to the local community. In turn, this affects the role of public agencies and their program planning and implementation efforts.

Information included in the Planner's Guide is keyed to major technical, economic, environmental, and institutional issues at specific sites. These issues are regarded as potential barriers to development and are grouped by resource areas so that individual programs can be examined in the context of the critical issues and multiple factors which influence the success of development. Ongoing electric power and direct-use projects as well as federal, state, local and private sector programs are discussed to show the interaction of various activities. Interested managers can use relevant issue clusters to design, evaluate, or monitor commercialization activities or to generate new insights which may better inform their understanding of geothermal development in California.

The conceptual design of the Planner's Guide is presented in Figure A. Sections 1 through 3 summarize the resource base, status of geothermal development activities, and the state's energy flow. The present and projected geothermal share of the energy market is discussed in Section 4. Sections 5 and 6 describe the public and private sector initiatives supporting geothermal development in California. These include legislation to provide economic incentives, streamline regulation, and provide planning assistance to local communities. Private sector investment,

Figure A. Conceptual Design of the Program Planner's Guide



* Not included in Planners Guide.
See Annual Workplans submitted
to DOE/DGE Headquarters.

research, and development activities are also described.

Each section of the guide is self-contained. Thus, if a reader is well informed about the topic of any section or subsection, it may be bypassed. If specific information from any section is desired, that section may be read without recourse to other sections. The self-sufficiency feature of each section is designed to facilitate the Guide's use as a planning document. However, this feature requires some unavoidable repetitions of material. The authors have endeavored to keep such repetitions to a minimum.

Appendices to the guide are intended to provide a ready reference of financial incentives under the Federal Energy Act, state legislation relevant to geothermal development, organizations and persons involved in geothermal commercialization efforts, and ongoing research programs.

It should be noted that the level of information on the market for electric power generation is substantially greater than that available for direct heat applications. Additional information will be included in future editions of the Guide as it becomes available.

Because geothermal energy development is a dynamic process, it is essential that planners be informed of significant events. The National Progress Monitor System (NPMS) was created in FY 79-80 to meet the continuing information needs of the federal geothermal program. The Planner's

Guide is designed to interface with this evolving information system which includes weekly and monthly reports from DOE regional offices and State Resource and Commercialization Teams. Since its first publication in 1979, significant events and developments have been reported in the Geothermal Progress Monitor (GPM). Section 7 of the Planner's Guide contains relevant excerpts from recent issues of the GPM as well as from other relevant reports published in 1980. It also directs readers to additional information available from state, local, and industry sources.

A major change during FY 1980 is the reorganization of the Division of Geothermal Resources Management (Assistant Secretary for Resource Applications) and the Division of Geothermal Energy (Assistant Secretary for Energy Technology) into one unit. The new Division of Geothermal Energy under Resource Applications combines resources assessment, technology research and development, and public outreach programs.

Finally, as the preparation of the Planner's Guide is part of a continuing geothermal policy project at Lawrence Berkeley Laboratory, readers with questions, suggestions, and comments are invited to contact

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1. RESOURCE PROFILE

DEVELOPMENT ACTIVITIES

ENERGY SUPPLY and DEMAND

GEOTHERMAL ENERGY MARKET

GOVERNMENT ACTIVITIES and INITIATIVES

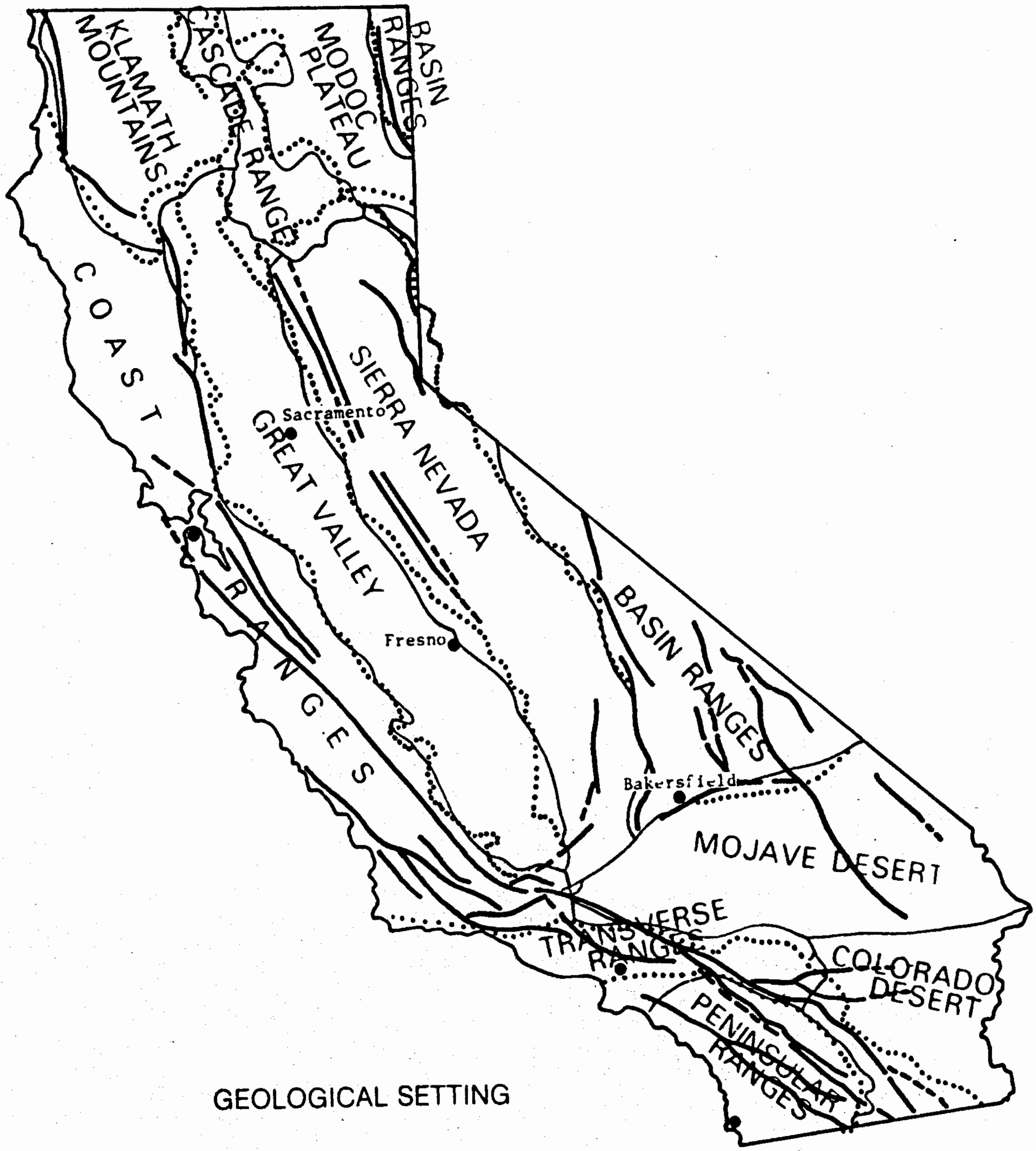
PRIVATE SECTOR ACTIVITIES

SIGNIFICANT EVENTS

SECTION 1. CALIFORNIA GEOTHERMAL RESOURCE PROFILE

California's diverse geologic setting leads to a correspondingly rich array of possibilities for resource development in the state. The information presented in this section indicates that there has been a substantial effort to identify the hydrothermal resource potential for electric applications. The efforts to assess the resource potential for hot dry rock and geopressured geothermal resources have not been assigned as high a priority. The potential for hot dry rock utilization in California is significant, as it is in most of the western states, and the technology needed to assess, confirm, and use this resource is being developed. The technology required for geopressured utilization is less sophisticated than that for hot dry rock, but the potential geopressured geothermal resources in California are believed to be relatively small.

In this section, the estimated potential and locations for hydrothermal, hot dry rock, geopressured, and magmatic systems in California are described. The section is a summary of the information that is readily available to the general public. Subsequent sections will outline the development activities presently in process in California's geothermal areas for both electrical and direct-use applications and will provide discussions of energy supply and demand, geothermal's market potential, and the significant areas of development activity in the public and private sectors.



GEOLOGICAL SETTING

XBL 806-1290

COUNTIES

1. Del Norte
2. Siskiyou
3. Modoc
4. Lassen
5. Shasta
6. Trinity
7. Humboldt
8. Tehama
9. Plumas
10. Butte
11. Glenn
12. Mendocino
13. Lake
14. Colusa
15. Stutter
16. Yuba
17. Sierra
18. Nevada
19. Placer
20. El Dorado
21. Sacramento
22. Yolo
23. Napa
24. Sonoma
25. Marin
26. Solano
27. Contra Costa
28. San Joaquin
29. Amador
30. Alpine
31. Calaveras
32. Toulumne
33. Stanislaus
34. Alameda
35. San Francisco
36. San Mateo
37. Santa Clara
38. Santa Cruz
39. Monterey
40. San Benito
41. Merced
42. Mariposa
43. Fresno
44. Madera
45. Mono
46. Inyo
47. Tulare
48. Kings
49. San Luis Obispo
50. Kern
51. San Bernardino
52. Los Angeles
53. Ventura
54. Santa Barbara
55. Orange
56. Riverside
57. San Diego
58. Imperial

Figure 1.1-1. California Geological Setting

Source: U.S. Geological Survey, National Atlas of the United States, 1971.

The focus of geothermal development work to date has been on hydrothermal resources. These systems are found in the Coast Range, in the volcanic mountains of northeastern California, along the eastern periphery of the Sierra Nevada, and throughout the deserts in the southern part of the state.

The greatest potential for hot dry rock development lies with the relatively recent volcanic systems scattered throughout northern and south central California.

Geopressured resources, by definition, are associated with deeply buried water-bearing rock. The best possibilities for discovery of this type of geothermal resource lie in the sediments of the Great Valley and Los Angeles and Ventura Basins, and in similar sediments off the northwest coast.

Magmatic geothermal resources are associated with active volcanic systems, like those on the island of Hawaii and in the Aleutian Islands in Alaska. Research into methods of tapping these resources is currently being conducted in Hawaii and Iceland. There are no active volcanoes in California today, but the Cascade Range in the northern part of the state includes a few potentially active systems, like Mt. Lassen.

1.2 CALIFORNIA'S GEOTHERMAL RESOURCES

In describing the geothermal resource base, the authors of Circular 790* have separated the aggregate geothermal resource available in the earth's crust into identified and undiscovered resources. Identified resources are further classified as useful and residual. Identified resources are those portions that are accessible; identified residual resources are those portions that cannot physically be recovered, principally because of depth or drilling limitations. Identified useful resources are further divided into economic and sub-economic categories. The calculated geothermal "reserve" is that portion of the useful identified resource base that is of economic interest.** The derivations of the terms resource and reserve are shown in Figure 1.2-1.

In the following discussion, a tabular summary of the identified hydrothermal resources in California will be given. Succeeding sections present the probable locations for hot dry rock geothermal and geopressured geothermal resources. However, since the majority of effort in exploration and development has focused on hydrothermal resources, the classifications of dry rock and geopressured resources are not as extensively developed.

HYDROTHERMAL RESOURCES

Data for hydrothermal resources are presented in three categories.*** Figure 1.2-2 shows the location of California's hydrothermal resources.

Vapor-dominated (steam) systems have the highest potential for rapid development. The characteristics of identified systems are described in Table 1.2-1.

Hot water hydrothermal systems (Table 1.2-2) with temperatures greater than 150°C (300°F) have great promise for electrical development, but the costs of development and the unsolved engineering problems are somewhat larger than those

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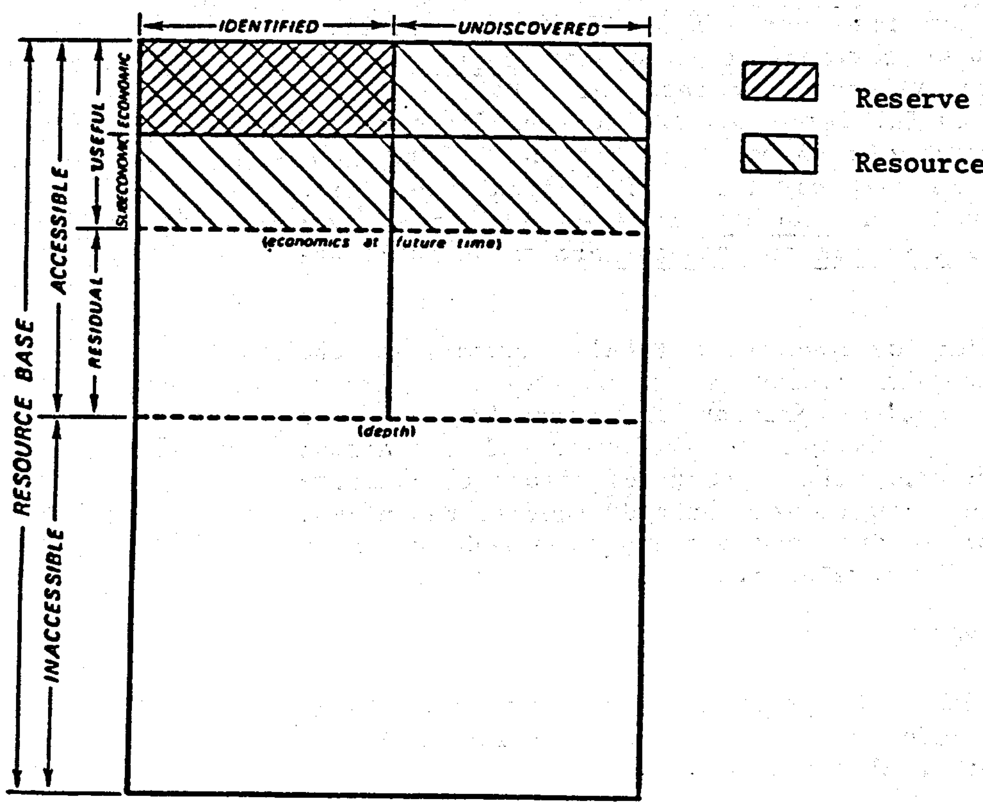
*The following resource information is taken largely from the data assembled for Assessment of Geothermal Resources in the United States - 1978, USGS Circular 790.[1] This circular contains the most recent information available from both federal and state sources, so only minor additions have been made to update this source.

** For a more detailed discussion, see reference 1, pp. 4-5.

*** Individual systems are described as they occur proceeding from the northern part of the state.

Figure 1.2-1. McKelvey Diagram for Geothermal Energy. Vertical axis is degree of economic feasibility; horizontal axis is degree of geologic assurance



Source: USGS Circular 790. Assessment of Geothermal Resources of the United States -- 1978.

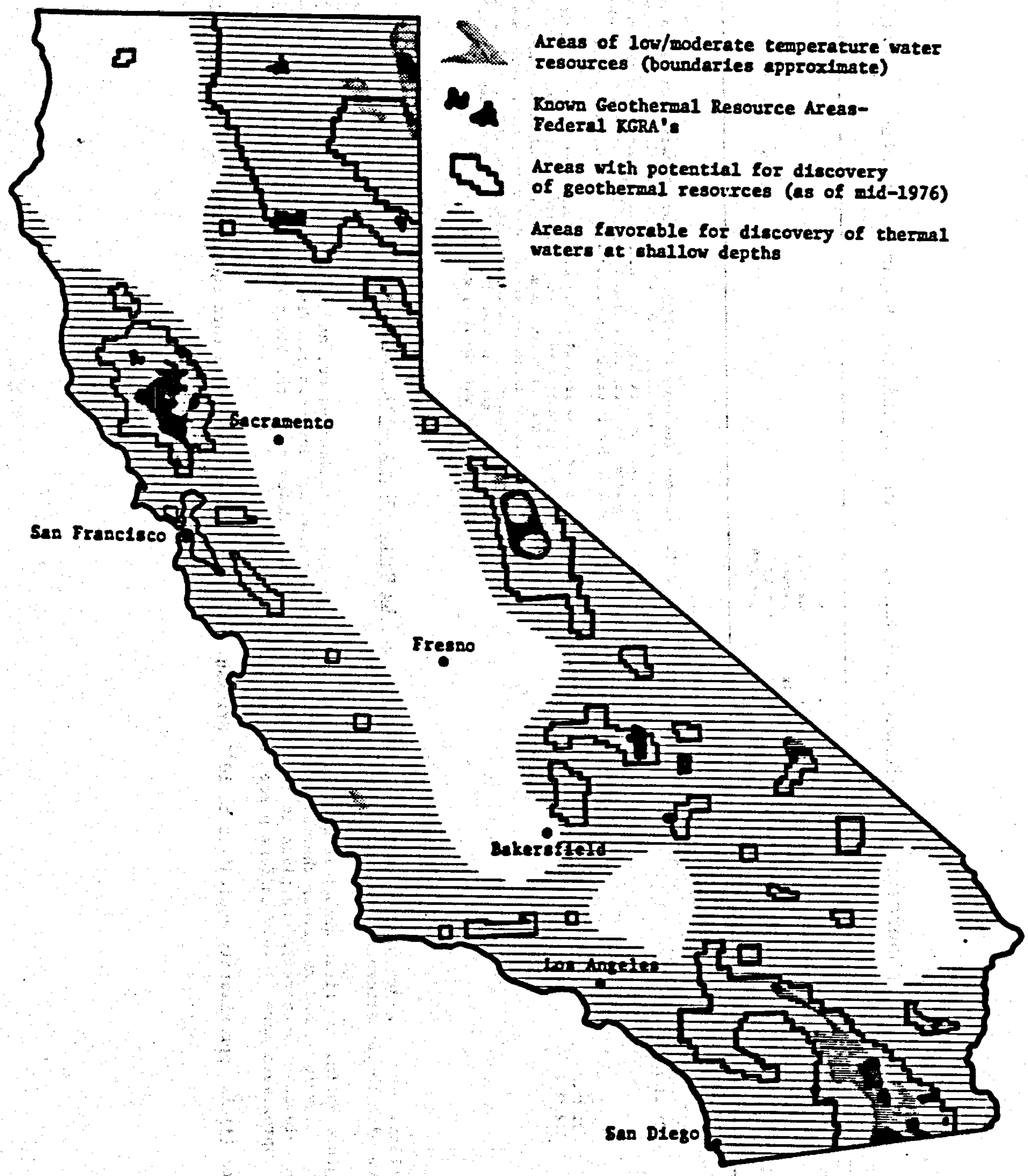
for vapor-dominated systems.

The third category, hot-water systems with temperatures between 90°C (200°F) and 150°C (300°F), will be developed primarily for direct heat uses in the near future. The characteristics of these low and moderate temperature resources are described in Table 1.2-3.

A great deal of information is now being collected on hydrothermal systems with reservoir temperatures less than 90°C (200°F). Technological limitations preclude their economical use for electrical production at the present time. A listing of these resources appears in Table 1.2-4.

Data collected on these low temperature resources is limited in comparison to the data collected for the higher

Figure 1.2-2. Location of California's Hydrothermal Resources.



Source: California Division of Mines and Geology 1980, and National Geophysical and Solar-Terrestrial Data Center, 1977.

Table 1.2-1. Locations, Temperatures, Volumes, and Energies of Identified Vapor-Dominated Systems

Name of area	Latitude (°N) Longitude (°W)	Estimates of reservoir temperature (°C)	Mean reservoir temperature (°C)	Mean reservoir volume (km³)	Mean reservoir thermal energy (10^{18} J)**	Comments	Electrical energy (MW_e for 30 yr)
Lassen	40 26.0 121 26.0	215 240 255	237 ± 8	71 ± 25	42 ± 15	Low-chloride and acid-sulfate character of thermal waters and presence of fumaroles suggest a vapor-dominated system, but this has not been confirmed by drilling. Temperatures are assumed to be similar to The Geysers. Area may range from 10 to 70 km². Withdrawn from commercial exploration or development because of National Park status.	--
The Geysers	38 48.0 122 48.0	215 240 255	237 ± 8	1167 ± 39	100 ± 24	Area may range from 60 to 120 km². Boundaries of the reservoir have not been exactly delimited, although unsuccessful step-out wells have been drilled at the northwest and southeast edges of the presently developed field. Reservoir probably extends deeper than 3 km. More than 200 wells have been drilled. Generating capacity in early 1979 will be 663 MW_e; facilities to generate an additional 320 MW_e are under construction and planned to be operational by mid 1980.	1610

Source: L.J.P Muffler. Assessment of Geothermal Resources of the United States--1978, Geological Survey Circular 790, prepared in cooperation with the Department of Energy, 1979.

*For reservoir temperature estimates, first number is most likely value, subscript is maximum value, and superscript is minimum value. Mean values of temperature, volume, and reservoir thermal energy are followed by standard deviations. Temperatures given to three significant figures; in most cases volumnes and energies are given to two significant figures. However, if the first digit is 1, three significant figures are given in order to approximate more closely uniform percentage accuracy.

**A unit of 10^{18} joules (j) is approximately equivalent to 10^{15} British thermal units (Btu) which in turn equals one quad (a quadrillion Btu).

Table 1.2-2. Locations, Temperatures, Volumes, and Energies of Identified Hot-Water Hydrothermal Convection Systems Greater than 150°C in California*.

Name of area	Latitude (°N) Longitude (°W)	Estimates of reservoir temperature (°C)	Mean reservoir temperature (°C)	Mean reservoir volume (km^3)	Mean reservoir thermal energy (10^{18} J)	Comments	Electrical energy (MW_e for 30 yr)
Surprise Valley area	41 40 120 12	129 143 (A) 185	152 ± 12	210 ± 90	79 ± 32	Four main groups of thermal springs and eight wells in zone about 20 km long; violent mud eruption in 1951. Deepest well drilled to over 2 km; maximum reported well temperature 160°C at 1.1 km.	1490
Morgan Springs-Growler Springs	40 23 121 31	176 230 245	217 ± 15	8.3 ± 2.6	4.5 ± 1.5	Several springs in two groups about 1.2 km apart; abundant sinter deposits. System may be larger and is probably related to the adjacent vapor-dominated system at Lassen. Surface temperatures to 95°C; discharge 350 L/min.	116
Sulphur Bank mine (Hot Bolata)	39 01 122 39	186 186 (M) 210	194 ± 6	6.7 ± 1.9	3.2 ± 0.9	Hot springs, fumaroles, and associated mercury and sulfur deposits. Four wells, deepest about 1.2 km; maximum reported temperature 186°C at about 0.4 km.	75
Clear Lake volcanic field area	38 55 122 43	165 195 (M) 210	190 ± 9	83 ± 35	39 ± 17	Several warm springs and local occurrences of sulfur deposition and gas seeps scattered throughout Quaternary volcanic field adjacent to The Geysers steam field. Few deep wells with unconfirmed temperatures as high as 270°C at 3 km depth. There is no evidence to indicate that the volcanic field is completely underlain by a hydrothermal convection system.	900
Long Valley caldera	37 40 118 52	200 230 250	227 ± 10	136 ± 36	78 ± 21	A deep (2.1 km) geothermal test well in the eastern part of the caldera encountered temperatures of only 72°C. The high-temperature system is probably confined to the western part of the caldera west of the Hilton Creek fault. Enthalpy-chloride relations indicate possible maximum temperature of 282°C.	2100
Coso area	36 03 117 47	190 230 240	220 ± 11	46 ± 12	25 ± 7	Surface activity consists of acid-sulfate springs and weak fumaroles. A geothermal test well 1,477-m deep encountered a chloride water at 1,064 m; maximum recorded temperature was 189°C at 628 m. Enthalpy-chloride relations indicate possible temperatures of 240° to 275°C.	650
Randsburg area	35 23 117 32	115 150 250	172 ± 29	9.4 ± 2.3	4.0 ± 1.2	One well 235 m deep; maximum recorded temperature 115°C. Hot water apparently flashes in borehole.	84
Salton Sea area	33 12 115 36	300 330 340	323 ± 8	116 ± 34	97 ± 28	More than 20 wells drilled to depths of 0.7 to 2.4 km; maximum reported temperature 360°C at 2.1 km. Produced fluids are hypersaline brines. A geothermal loop experimental facility is currently being tested.	3400

Table 1.2-2 Continued

Westmorland	33 05 115 39	200 215 235	217 ± 7	123 ± 35	67 ± 19	No surface discharge. Six geothermal test wells, maximum depth about 2.6 km. Temperatures at 1.9 km average between 190°C and 250°C. May be extension of the Salton Sea system.	1710
Brawley	33 03 115 32	230 250 280	253 ± 10	34 ± 8	22 ± 5	No surface discharge. About 6 wells, deepest about 4 km; maximum reported temperature 262°C at 2.4 km in brine. May consist of two separate systems.	640
East Mesa	32 47 115 15	165 180 200	182 ± 7	36 ± 7	16.3 ± 3.0	No surface discharge. Twenty or more wells between about 0.9 and 2.8 km deep; maximum reported temperature 204°C at 2.3 km in brine. A 10 MW_e binary cycle plant designed for a working temperature of about 180°C is under construction; additional facilities to produce 48 MW_e are planned.	360
Border	32 44 115 07	150 (O) 160 (O) 170 (O)	160 ± 4	4.0 ± 0.6	1.57 ± 0.25	No surface discharge. Area identified by temperature gradient anomaly. Estimated reservoir temperatures may be too high.	31
Heber	32 43.0 115 31.7	160 180 185	175 ± 5	71 ± 14	31 ± 6	No surface discharge. Eleven wells between 0.9 and 3.3 km deep. Average bottom hole temperature is 180°C; maximum field temperature is about 190°C. Plans to develop a 50 MW_e plant have been announced.	650

Source: L.J.P. Muffler, Assessment of Geothermal Resources of the United States--1978, Geological Survey Circular 790, prepared in cooperation with the Department of Energy, 1979.

* For reservoir temperature estimates, first number is most likely value, subscript is maximum value, and superscript is minimum value.

**A unit of 10^{18} joules(j) is approximately equivalent to 10^{15} British thermal units(Btu) which in turn equals one quad (a quadrillion Btu).

Table 1.2-3. Locations, Temperatures, Volumes, and Thermal Energies of Identified Hot-Water Hydrothermal Convection Systems 90-150°C in California*

Name of area	Latitude (°N) Longitude (°W)	Estimates of reservoir temperature (°C)	Mean reservoir temperature (°C)	Mean reservoir volume (km³)	Mean reservoir thermal energy (10^{18} J)**	Comments
Fort Bidwell area	41 51.0 120 09.6	99 126 179	135 ± 17	3.3 ± 0.9	1.00 ± 0.34	Five springs to 45°C discharging 400 L/min. Geothermometer temperatures may be unreliable: low surface temperature and high flow rate suggest that reservoir temperatures may be nearer the minimum estimate, or the waters may be mixed.
West Valley Reservoir Hot Spring	41 11.5 120 23.1	130 130 152	143 ± 3	3.3 ± 0.9	1.15 ± 0.32	Spring(s) discharging 12 L/min at 77°C. Sulfate-water isotope geothermometer indicates temperatures above 200°C.
Bassett Hot Spring	41 00.7 121 06.6	88 89 117	98 ± 7	3.3 ± 0.9	0.74 ± 0.22	Spring(s) discharging 200 L/min at 79°C.
Kelly Hot Spring	41 27.5 120 50.0	95 116 143	118 ± 10	3.3 ± 0.9	0.93 ± 0.27	One spring discharging 1250 L/min at 91°C. Two wells 970 and 1035 m deep; maximum reported temperature 116°C at 1035 m. Sulfate-water isotope geothermometer indicates temperatures near 200°C.
Big Bend Hot Springs	41 01.3 121 55.1	92 120 137	116 ± 9	3.3 ± 0.9	0.91 ± 0.27	Six springs to 82°C discharging about 340 L/min.
Wendel-Amedee area	40 18 120 11	107 128 143	126 ± 7	10.6 ± 3.0	3.2 ± 0.9	Several springs to 96°C discharging about 3600 L/min. Six wells (including two deep tests) 58 to 1538 m deep; maximum reported temperature 107°C at 330 m; temperatures not available for the two deep wells. Water from Wendel Hot Springs used in greenhouse operation.
Sierra Valley area	39 42.7 120 19.3	109 131 136	125 ± 6	10.0 ± 3.2	3.0 ± 1.0	No natural surface activity. One geothermal test well 680 m deep; seven shallower artesian wells used for stock watering; surface temperatures range from 39° to 94°C; total discharge exceeds 240 L/min.
Wilbur Springs area	39 02.2 122 25.2	141 141 150	144 ± 2	12.5 ± 4.0	4.4 ± 1.4	Several springs in four groups with temperatures to 67°C and aggregate flow of less than 100 L/min. Two wells; maximum temperature 141°C at 1132 m.
Chalk Mountain area	39 04.8 122 35.0	105 105 128	113 ± 5	3.3 ± 0.9	0.88 ± 0.25	Area of sulfur fuming and hydrothermally altered rock; warm springs with temperatures to 24°C discharging 11 L/min. Geothermometer temperatures are probably not reliable because of low flow rate, high Mg and HCO_3 concentrations, and likelihood of near-surface reactions.

Table 1.2-3 Continued

Skaggs Hot Springs	38 41.5 123 01.5	95^{95}_{150}	113 ± 13	3.3 ± 0.9	0.88 ± 0.28	Three springs to 57°C discharging 57 L/min. Geothermometer temperatures are in doubt owing to low flow rate.
Calistoga Hot Springs	38 34.9 122 34.4	141^{137}_{153}	144 ± 3	6.9 ± 1.9	2.4 ± 0.7	Several springs and wells, including one geysering well; maximum well temperature 137°C at 610 m (?); silica deposits in well pipes.
Grovers Hot Springs	38 41.9 119 51.6	130^{110}_{137}	126 ± 6	3.3 ± 0.9	1.00 ± 0.28	Two main springs to 64°C discharging 400 L/min.
Fales Hot Springs	38 20.0 119 24.0	119^{84}_{145}	116 ± 12	3.3 ± 0.9	0.91 ± 0.28	Several springs to 61°C discharging more than 1000 L/min. One well 126 m deep. Geothermometer temperatures may be inaccurate owing to CO_2-rich water and calcite precipitation. Sulfate-water isotope geothermometer gives about 130°C. Extensive travertine deposits.
Buckeye Hot Spring	38 14.3 119 19.6	122^{87}_{122}	101 ± 8	3.3 ± 0.9	0.77 ± 0.23	Spring(s) to 64°C discharging 400 L/min; fossil travertine deposits.
Travertine Hot Springs area	38 14.8 119 12.1	110^{87}_{137}	111 ± 10	3.3 ± 0.9	0.87 ± 0.26	Several springs in two groups about 2.5 km apart; temperatures to 69°C; total discharge 135 L/min. One well 300 m deep. Extensive travertine deposits.
North Shore Mono Lake (Black Rock Point Hot Spring)	38 02.4 119 04.8	94^{85}_{122}	100 ± 8	3.3 ± 0.9	0.77 ± 0.23	Spring(s) to 66°C discharging 150 L/min; travertine deposits. One well about 3 km to the south had maximum temperature of 57°C at 743 m (TD).
Tecopa Hot Springs	35 53.2 116 14.2	137^{97}_{145}	126 ± 10	3.3 ± 0.9	1.00 ± 0.30	Springs to 48°C discharging 15 L/min. Geothermometer temperatures may be unreliable due to likelihood of reaction of water with tuffaceous lacustrine rocks.
Scovern Hot Spring	35 37.1 118 28.4	114^{85}_{119}	106 ± 7	3.3 ± 0.9	0.82 ± 0.24	Spring discharging 435 L/min at 53°C.

Source: L.J.P. Muffler . Assessment of Geothermal Resources of the United States--1978, Geological Survey Circular 790, prepared in cooperation with the Department of Energy, 1979.

* For reservoir temperature estimates, first number is most likely value, subscript is maximum value, and superscript is minimum value.

**A unit of 10^{18} joules(j) is approximately equivalent to 10^{15} British thermal units(Btu) which in turn equals one quad (a quadrillion Btu).

Table 1.2-4. Areas Favorable for Discovery and Development of Local Sources of Low-Temperature (less 90°C) Geothermal Water in California.

Name of area	Wells considered			Thermal springs		Thermal gradients	Dissolved solids	Remarks
	No.	Depths (m)	Temperature (°C)	No.	Temperature (°C)	(°C/km)	(mg/L)	
Surprise Valley	4	60-655	40-139	10	21-86	40-80	350-1,200	Deep circulation in Surprise Valley fault zone with possible magmatic source at depth. Aquifers in valley-fill deposits; thermal waters may originate in Miocene volcanic rocks of the Cedarville Series. Includes Lake City KGRA, Surprise Valley high-temperature system.
Kelly Hot Springs	8	60-977	27-110	3	27-33	120	900-1,200	Deep circulation in Likely fault and associated fault zones. Aquifers in Pliocene and Pleistocene volcanic rocks and lake sediments, and the Miocene Cedarville Series of Russell (1928). Includes Kelly Hot Spring (92°C) high-temperature system.
Susanville	2	90, 180	36, 49	—	—	High	200-600	Deep circulation in fault zones. System appears to be unrelated to nearby Wendell-Amedee Hot Springs.
Sierra Valley	10	7-3[illegible]	39-94	1	30	140-250	800-1,500	Deep circulation in Hot Springs fault. Aquifers are permeable zones in lake-bed sediments and late Tertiary volcanic rocks. Includes Beckwourth KGRA.
Lovelady - Wilbur Hot Springs	—	—	—	7	27-67	—	—	Includes Lovelady Ridge KGRA, Wilbur Hot Springs high-temperature system.
The Geysers	—	—	—	—	—	—	—	The Geysers region contains many hot springs issuing from hot-water systems that are not contained within the vapor-dominated field. The area depicted on the map generally encloses these springs.
Bridgeport	2	201, 299	50	3	35-65	134, 143	3,000-4,500	Deep circulation in Pliocene caldera. Aquifer: fractured volcanic rocks.
Mono Lake	2	245, 743	53, 58	5	33-95	34, 106	1,200-26,000	Deep circulation in region of young silicic volcanism. High-salinity waters probably mixed with Mono Lake water. Includes Mono Lake KGRA.
Long Valley	—	—	—	25	34-90	—	[illegible] 1,400	Long Valley KGRA. Low-temperature thermal waters at depths less than 1 km in the Long Valley geothermal system generally are mixtures of deep thermal waters and shallow meteoric waters. Consult the reference for detailed studies and data.
Paso Robles	4	<300	7 -47	3	35-50	90	610	Deep circulation in Pliocene and (or) Pleistocene continental sediments (Paso Robles Formation).
Tecopa	1	122	48	5	27-43	230	—	Deep circulation along Basin and Range faults. Aquifers in valley-fill deposits.

Table 1.2-4 continued

Trona	4	92-182	30-58	1	33	133, 209	Briny	Deep circulation in Basin and Range faults(?). Water from playa sediments mined for salts.
Imperial - Coachella Valleys	—	—	—	—	—	—	—	A vast low-temperature geothermal resource is believed to be present in a continuous zone extending from the north end of the Coachella Valley (Desert Hot Springs area) to the Mexican border. Within this area are the Salton Sea, Brawley, Glamis, East Mesa, Heber, and Dunes KGRA's, all containing high-temperature resources. The resource, except for that in the Coachella Valley, is described in a voluminous literature. In the Coachella Valley, 14 wells <150 m deep have temperatures ranging from 39° to 98°C. Dissolved solids range from 290 to 1,290 mg/L (Moyle, 1974). The source of heat is assumed to be deep circulation in faults lying between the San Andreas and San Jacinto fault zones, with a probable magmatic source at depth.
Ocotillo Hot Spring	8	45-365	31-39	—	—	53-360	—	Deep circulation in San Jacinto fault zone.

Source: L.J.P. Muffler. <u>Assessment of Geothermal Resources of the United States--1978</u>, Geological Survey Circular 790, prepared in cooperation with the Department of Energy, 1979.

temperature hydrothermal resources. However, the large number and distribution of these low temperature resources imply great potential for direct applications.*

HOT DRY ROCK

The assessment of hot dry rock (HDR) geothermal resources in California, as in most of the United States, is still in its preliminary stages.

In Figure 1.2-3, areas with high temperature gradients (°C/km) in California are outlined. Areas with high temperature gradients would exhibit more potential for hot dry rock development because of the inference of higher rock temperatures at shallower depths.

The method employed to outline areas in Figure 1.2-3 is not refined enough to lend the same significance as a KGRA, but the physical extent of the areas mapped so far, and speculation that further potential exists in the volcanic regions of the northeast part of the state, are encouraging from the standpoint of resource potential. Identification of HDR systems involves the location of a mass of relatively impermeable rock, with adequate temperature, at a reasonable depth. HDR may be extremely attractive as a potential energy source. At present, the technical problems of HDR reservoir production are unsolved. The ultimate question is whether energy can be produced at competitive prices.**

In California, a number of volcanic systems with HDR potential have been identified and estimates given for the thermal energy remaining in these systems. (See Table 1.2-5)

These thermal calculations are based on three factors: an estimate of the size of the system, the geologic age of the system, and the assumption that the magma cooled from an initial temperature of 850°C.[2] Only systems that are of significant size and that have inferred magma chambers at relatively shallow depths are listed. Development of the necessary exploration techniques, the technology needed to produce sufficient fracturing in the rock to enable reservoir development, and supporting economic feasibility studies are

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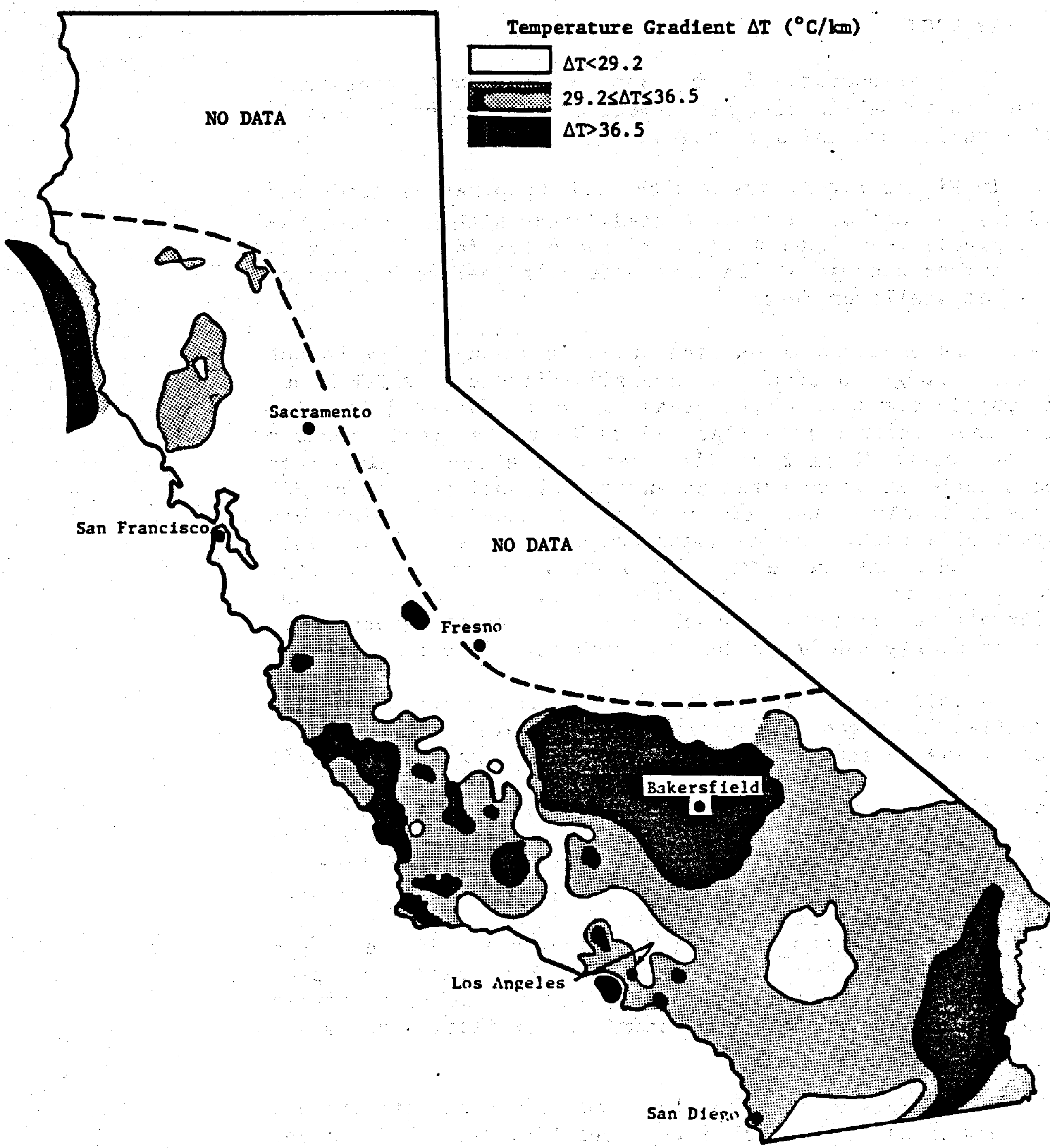
* An update of the low and moderate temperature resources is available from the Division of Mines and Geology, California Department of Conservation.

** The magnitude of the resource may be enormous. If one were to assume that less than one percent of this nation's HDR resource base were recoverable, the amount of thermal energy available would be comparable to the estimated resource base of all the coal remaining in the U.S.[3]

Figure 1.2-3. Preliminary Geothermal Gradient Map



Source: R. Potter, LASL (Preliminary Source: AAPG Gradient Maps).

XBL 806-1287

Table 1.2-5. Thermal Energy Still Remaining in Igneous Systems in California

Name of area	Thermal energy remaining in system (10^{18} joules)*
Lassen Peak	960
Clear Lake	3610
Long Valley	5780
Salton Sea	480
Coso Mountains	1570
Mono Domes	1570
Medicine Lake	724
Shasta	724
Sutter Buttes	less than 42
Big Pine	less than 85
Templeton Domes	603

Source: USGS Circular 790, Assessment of Geothermal Resources of the United States--1978.

*A unit of 10^{18} joules (J) is approximately equivalent to 10^{15} British thermal units (Btu) which in turn equals one quad (a quadrillion Btu).

being managed by the Los Alamos Scientific Laboratory in New Mexico. Future efforts to develop these resources will depend largely on the success of the present research and demonstration projects in proving reservoir development techniques and economic viability.

GEOPRESSURED GEOTHERMAL RESOURCES

The effort to identify geopressured resources in California is in its formulative stages. Assessment of geopressured resources is being carried out primarily in the Gulf Coast area, where the identified potential is the greatest. A number of tests, using unsuccessful oil exploration wells that have penetrated these geopressured zones in the Gulf, have been evaluated.

Several factors affect the economic feasibility of geopressured systems. The cost of drilling the wells and establishing sufficient fluid flows may be prohibitive at the depths involved. The temperature of the water determines the range of applications for which it can be used (electricity or direct use, or both). The most important economic factor is the volume of methane dissolved in the water. This gas can be extracted and sold separately.

Several areas in California have been identified as prospects for geopressured development. (See Figure 1.2-4 and Table 1.2-6)

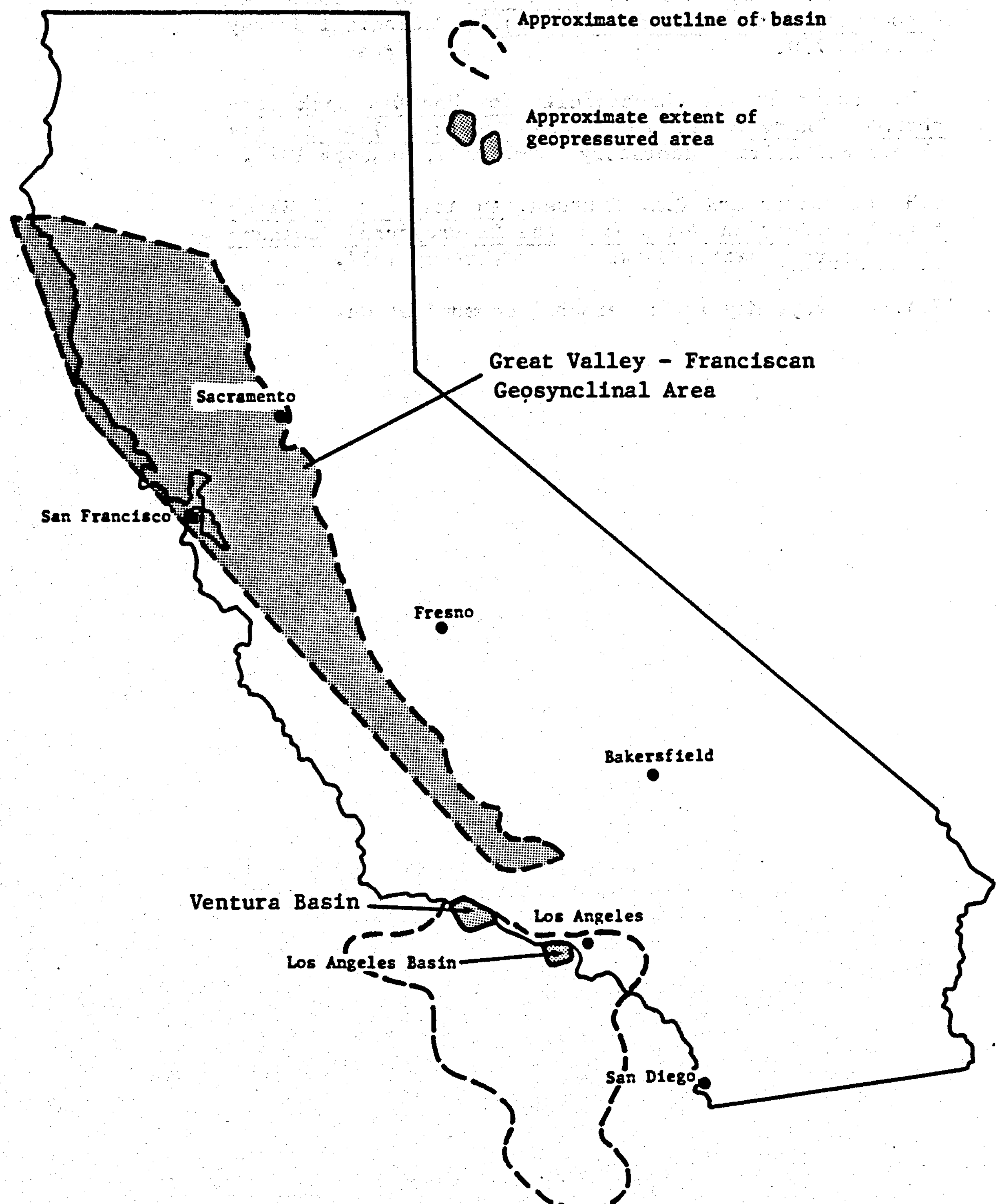
Table 1.2-6. Geopressured Basins in California

Geologic Basins: Great Valley miogeosyncline Franciscan eugeosyncline, Santa Barbara Channel, Los Angeles, Ventura and Tanner Banks basins: California onshore-offshore.	Geologic Ages and/or formations: Cenozoic and Mesozoic formations (Pliocene to Jurassic age). Approximate depth range: 400 ft. (122 m) to 17,700 ft. (5395 m). Approximate fluid-pressure range: 0.44 to 1.00 psi/ft. (9.9 to 22.6 kPa/m). Approximate temperature range: <100°F to 390°F (<38°C to 199°C) Probable Geopressuring mechanism: Horizontal compression (dynamic loading); internal forces; uplift; resistance to fluid expulsion.

Source: Circular 790, Assessment of Geothermal Resources of the U.S. - 1978. USGS, Table 19 - General Description of the geopressured basins of the U.S. (pp. 98-99).

The San Joaquin-Sacramento Valley and the Los Angeles and Ventura basins are areas with deeply buried sediments with some known geopressured potential. Some work is now underway to evaluate further the potential of these areas. The possibility exists for discovery of geopressured resources with significant methane content in the deep sediments of the Central Valley and California coast, but the temperature of these waters might not be high enough for economical applications.

Figure 1.2-4. Geopressured Basins of California



Source: USGS Circular 790 - 1978.

XBL 806-1292

REFERENCES

1. L.J.P. Muffler, editor, Assessment of Geothermal Resources of the United States-1978, Geological Survey Circular 790.

2. J.W. Tester et al., Electricity for Hot Dry Rock Geothermal Energy: Technical and Economic Issues, Los Alamos Scientific Laboratory, LA-7603MS, January 1979.

3. C.H. Bloomster and C.A. Knutsen, An Analysis of Electrical Production Costs from the Geopressured Geothermal Resource, Battelle NWL-2192, February 1977.

4. F.A.F. Berry, May 1979: personal communication.

RESOURCE PROFILE

2. DEVELOPMENT ACTIVITIES

ENERGY SUPPLY and DEMAND

GEOTHERMAL ENERGY MARKET

GOVERNMENT ACTIVITIES and INITIATIVES

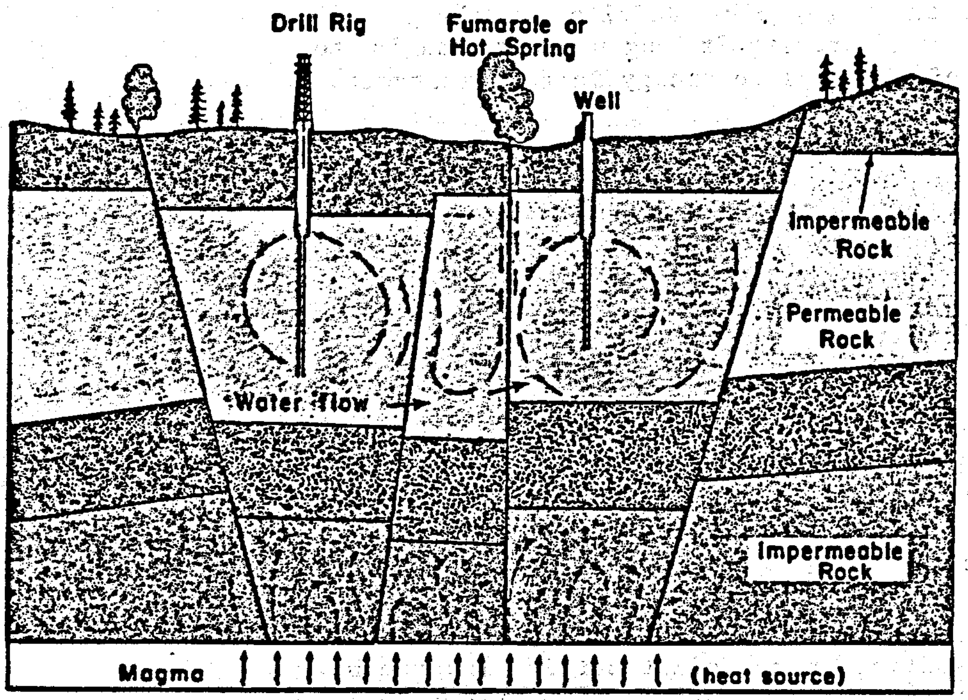
PRIVATE SECTOR ACTIVITIES

SIGNIFICANT EVENTS

SECTION 2. CURRENT GEOTHERMAL DEVELOPMENT ACTIVITIES IN CALIFORNIA

Geothermal development begins with the discovery and definition of resources sufficient to support an economic application. Identified resources may be used for electricity generation or direct heat applications in space heating, agriculture or industry, or both. Figure 2-1 is a schematic diagram of the development of a geothermal field.

FIGURE 2-1. Development of a Hydrothermal Reservoir



- Exploration Methodology

Surface manifestations, such as fumaroles and hot springs, are telltale indications of heat energy that encourage geothermal exploration. Magnetic and gravity surveys are used to find regional geothermal anomalies. Geophysical surveys measuring electrical resistivity are commonly used to estimate the physical extent of the geothermal reservoir. Geochemical analyses of water samples from wells and springs provide clues to reservoir temperature. Finally, shallow wells are drilled to allow measurement of the temperature gradients and to locate sites for deep exploratory wells.

These exploration techniques, which require a significant capital investment, are commonly used for the development of electric-power geothermal resources. At present, the resources assessment process for direct applications is more abbreviated because the applications contemplated do not justify the expense.

- Measurement of the Resource

When exploration indicates a potential economic resource (and acceptable land holdings, geothermal rights, or geothermal leases are obtained by the developer), deep exploratory wells are drilled to estimate the size, quality, and productivity of the reservoir. Results of these well tests are compared with reservoir engineering models to estimate the amount of recoverable energy in the reservoir.

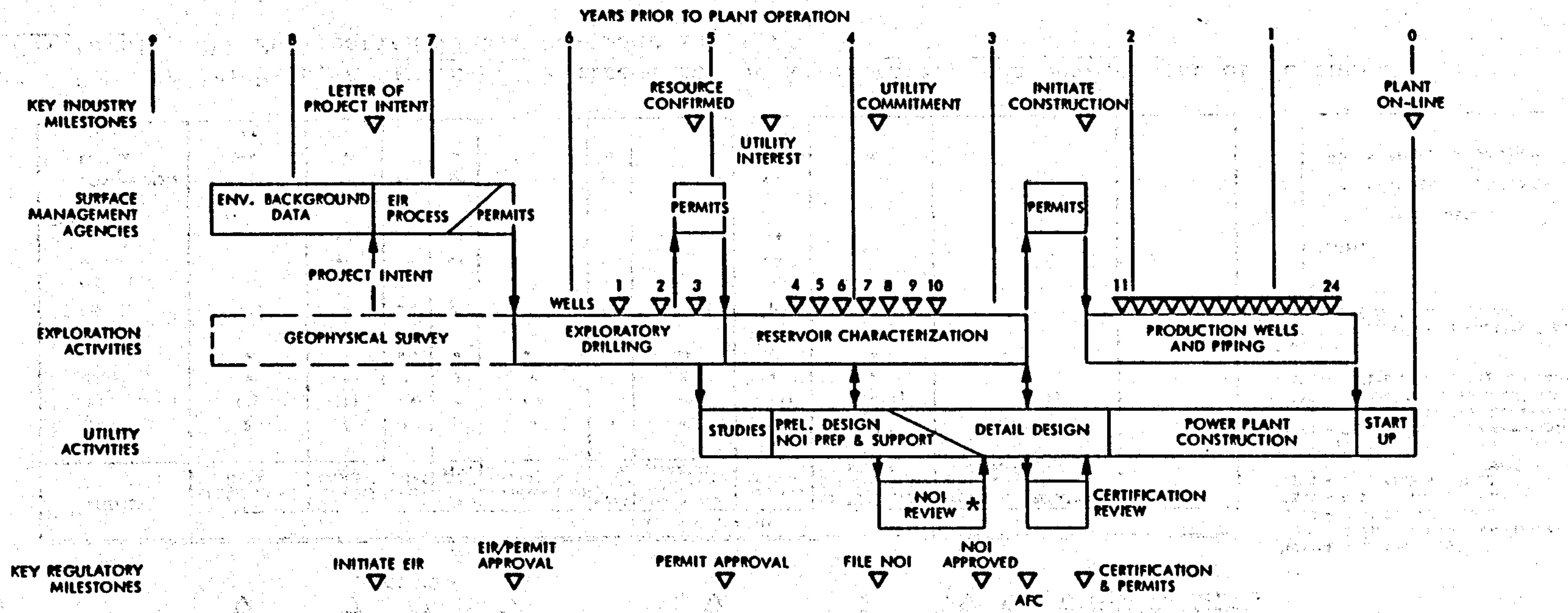
- Production Drilling

Once adequate resources are proven and a commercial use identified, wells are drilled for production of the geothermal reservoir and, if necessary, for injection of spent fluids. The fluid (vapor or water) may be used to produce electricity through direct application to a turbine-generator, or it may be passed through a heat exchanger (binary cycle) system which transfers heat to a working fluid which then drives a turbine-generator. The fluid may also be used for industrial processes, food processing, space heating and cooling, or other non-electric purposes.

- Power Plant Development

Power plant development usually follows the confirmation of a resource sufficient to enlist utility investment. Preliminary design studies by the utility may begin during the last stages of reservoir characterization. Detailed plant designs are completed after necessary permits for production wells and construction of facilities are granted. A new plant usually goes through a start-up period when the final operating procedures are tested and refined. Figures 2-2 and 2-3 show typical flow charts for a geothermal electric generation development on private and federal lands. These charts show the approximate time needed to bring the first electricity generating plant (50 MWe) on-line for a hypothetical geothermal resource, as well as listing the relevant regulatory agencies involved. The agencies with responsibilities for management of the public lands are described in Section 2.2. The activities of agencies involved in power plant siting, environmental regulation, and facilities operation are discussed in Section 5.22.

Figure 2-2. Geothermal Development of Private Lands (1st 50 MWe Plant)



AGENCY	REGULATORY ACTIVITY: BACKGROUND DATA	EIR PROCESS	EXPLOR-ATION PERMITS	EXPLORATION OPERATIONS	CHARACTER-IZATION PERMITS	CHARACTER-IZATION OPERATIONS	NOI REVIEW*	CERTIFICATION & PERMITS	DRILLING OPERATIONS & PLANT CONSTRUCTION
STATE:									
CEG	**	*					P	P	
PUC							*	*	
DOG	**	**	P	P	P	P		P	P
DFG	*	*	*		*		*	*	**
OPR		**					**	**	
COUNTY:									
PLANNING COMMISSION	P	P	P	P	P	P	*	*	P
RWQCB	**	*	*		*		**	*	
APCD	*	*	*	*	*	*	*	*	*

LEGEND:
P = LEAD AGENCY
* = RESPONSIBLE AGENCY
** = REVIEWING AGENCY

Federal agencies:
BLM - Bureau of Land Management
USFS - U.S. Forest Service
USGS - U.S. Geological Survey
USFWS - U.S. Fish and Wildlife Service

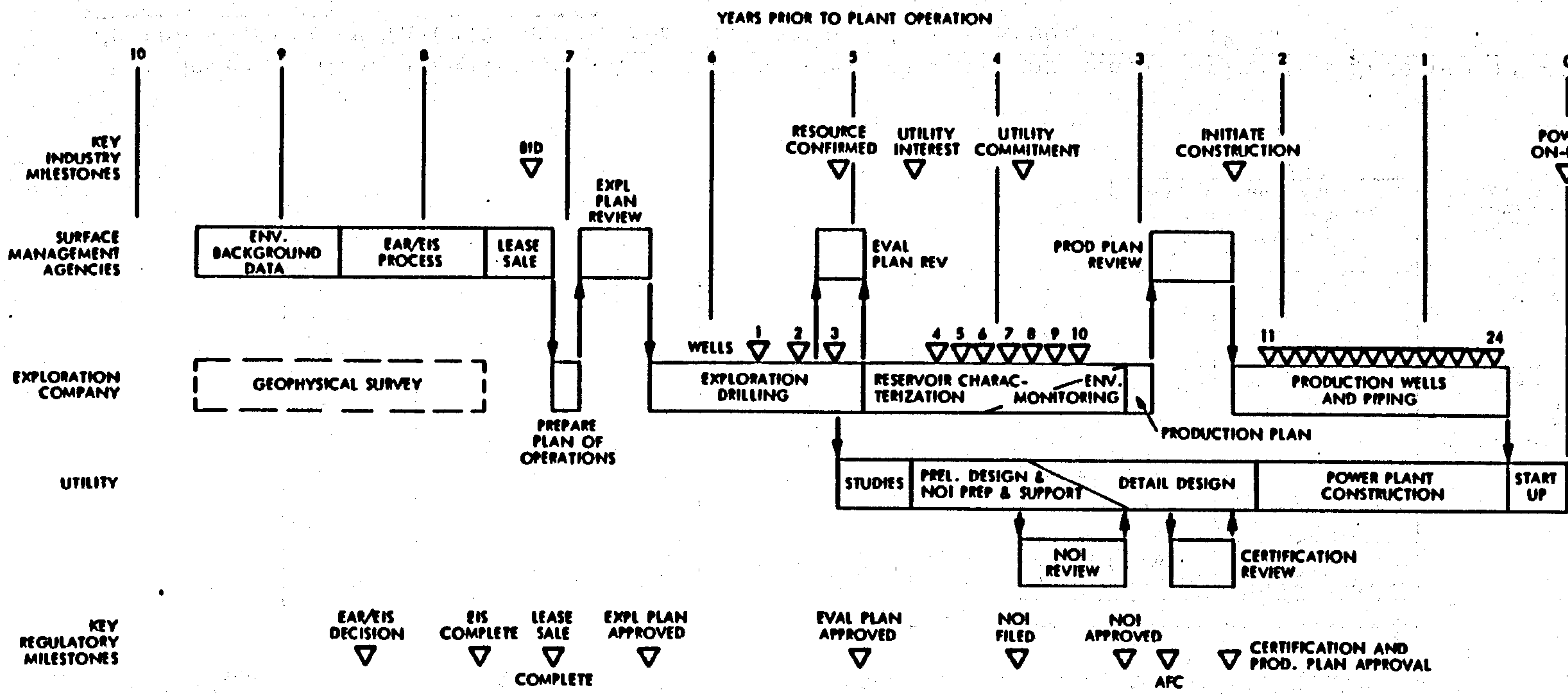
State agencies:
CEC - California Energy Commission
PUC - Public Utilities Commission
DFG - Department of Fish and Game
OPR - Office of Planning and Research

County agencies:
RWQCB - Regional Water Quality Control Board
APCD - Air Pollution Control District

Source: C.D. Fredrickson, Analysis of Requirements for Accelerating the Development of Geothermal Energy in California, JPL Publication 77-63, November 15, 1977.

* Geothermal plants are exempt from NOI process if located on proven resources.

Figure 2-3. Geothermal Development of Federal Lands (1st 50MWe Plant)



AGENCY	REGULATORY ACTIVITY: BACKGROUND DATA	EAR/EIS PROCESS	LEASE SALES	OP. PLAN REV.	EXPLORATION OPERATIONS	EVAL PLAN REV.	CHARACTERIZATION OPERATIONS	NOI REVIEW	CERTIFICATION & PROD. PLAN REVIEW	DRILLING OPERATIONS & PLANT CONSTRUCTION	
FEDERAL:											
BLM	P	P	P	•	•	•	•	P	•	•	
USFS	(1)	(1)	••	•	••	•	••	•(1)	•(1)	•(1)	
USGS	•	•	P	P	P	P	P	•	P	P	
USFWS	•	•	••	•	••	•	••	•	•		
STATE:											
CEC		•	••					P	P		
PUC								•	•		
DFG		••		••		••		••			
OPR		••						••			
COUNTY:											
PLANNING COMMISSION		••	••	••		••		••	••	•	
RWQCB	••	•		•		•		••	•		
APCD	••	•		•		•		•	•		

Federal agencies:
BLM - Bureau of Land Management
USFS - U.S. Forest Service
USGS - U.S. Geological Survey
USFWS - U.S. Fish and Wildlife Service

State agencies:
CEC - California Energy Commission
PUC - Public Utilities Commission
DFG - Department of Fish and Game
OPR - Office of Planning and Research

County agencies:
RWQCB - Regional Water Quality Control Board
APCD - Air Pollution Control District

LEGEND:
P = LEAD AGENCY
• = RESPONSIBLE AGENCY
•• = REVIEWING AGENCY

Source: C.D. Fredrickson, Analysis of Requirements for Accelerating the Development of Geothermal Energy in California, JPL Publication 77-63, November 15, 1977.

(1) USFS is lead on Forest Service Lands
* Geothermal plants are exempt from NOI process if located on proven resources.

In California, geothermal energy has been used for a small number of direct applications - e.g., space heating, agriculture, and aquaculture. The variety of potential direct uses is great and the list of new applications is continually growing. Because direct heat applications are still at a very early stage of evolution, little information is presently available on the development process. Thus, the development of direct application projects cannot be analyzed in the same way as for electrical applications.

The discussion in this section is divided into Pre-Exploration and Field Development Activities (Section 2.1) and Description of Significant Development Activities (Section 2.2). Section 2.1 outlines the use of designations for Known Geothermal Resource Areas (KGRAs). The functions of the land management agencies with responsibilities for regulation of exploration, leasing, and drilling activities are described. The status of existing and planned projects for electricity generation and direct heat use is summarized in Section 2.2.

2.1 PRE-EXPLORATION AND FIELD DEVELOPMENT ACTIVITIES

KNOWN GEOTHERMAL RESOURCE AREAS (KGRAs) IN CALIFORNIA

Federal Lands

Almost 1.5 million acres in the state of California have been classified by the USGS into 23 separate Known Geothermal Resource Areas (KGRAs). The California KGRAs constitute almost one-third of the lands that have been designated as KGRAs in the nation, and cover more than twice the acreage of KGRAs in Nevada, the state with the second largest total. The location and size of KGRAs and geothermal resource regions are shown in Figure 2.1-1.*

The federal government designates a KGRA based on one of two considerations. First, if geologic evidence suggests there is good geothermal potential for an area, the area geologist may designate this area as a KGRA.** Second, if the lease applications received by the surface agency overlap by 50 percent or more, the area is automatically designated a KGRA.

Lands designated as a KGRA must be leased through a competitive bidding procedure supervised by the surface management agency. Geothermal leasing on lands not designated as a KGRA is termed non-competitive, and transactions are usually carried out under less formalized procedures. The federal government may withdraw a KGRA designation. This would normally be done after two unsuccessful bidding offers.

State Lands

Historically, the California State Lands Commission (SLC) used the designation of Geothermal Resource Area for state lands based solely on good geologic potential for geothermal development. A recent legislative revision to the Geothermal Resources Act of 1967 provides that competitive bidding can be applied to any state land whether it is contained in a Geothermal Resource Area or not. For this reason, the designation is no longer used officially by state agencies.

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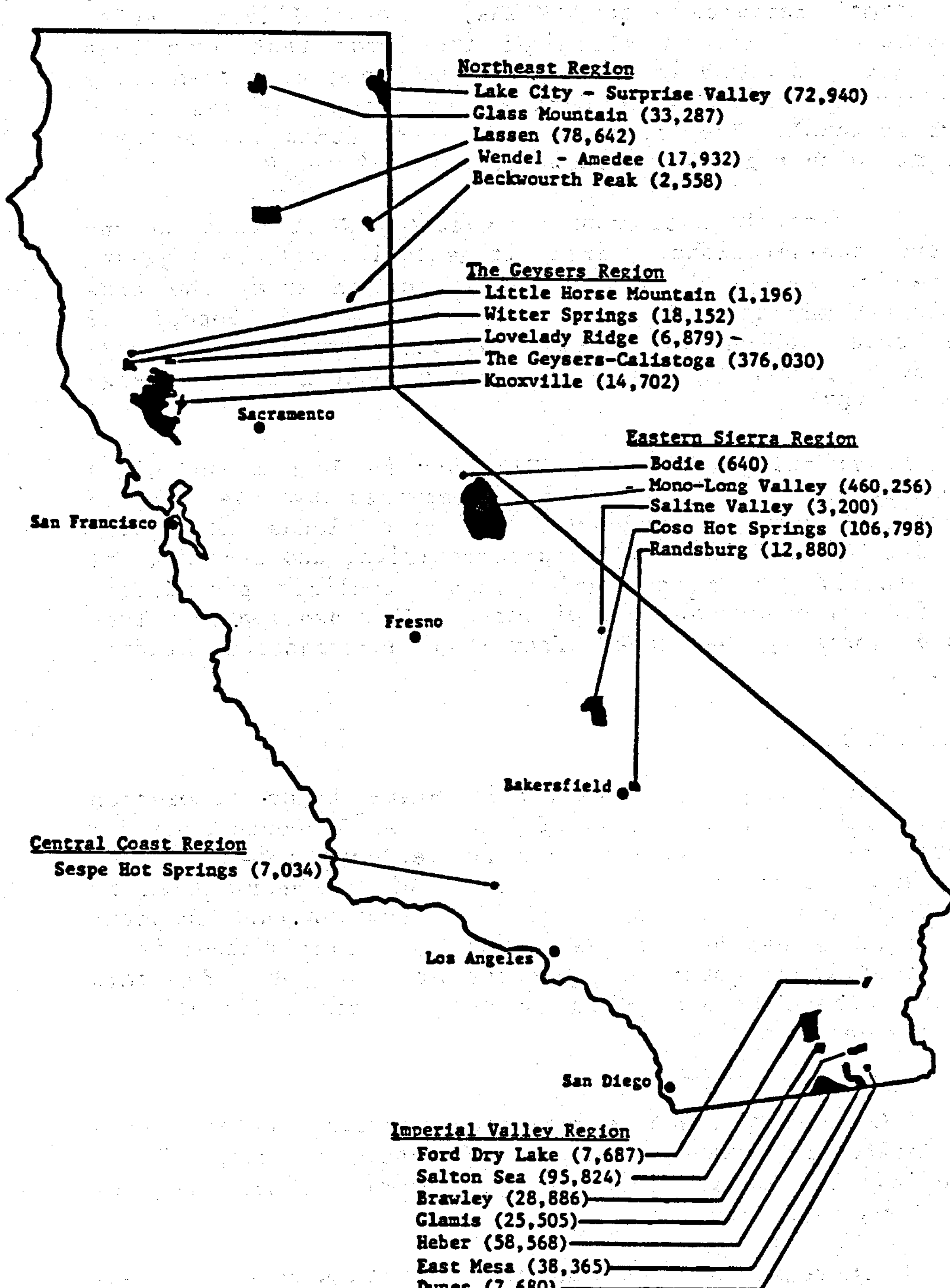
* Geothermal resource regions is a term sometimes used by California state agencies and refers to geographical groupings of KGRAs. The five geothermal resource regions are shown on Figure 2.1-1.

** There is some movement to limit KGRAs to those areas with electrical potential only. However, this issue may be moot because those areas with the best potential have already been designated as KGRAs.

Figure 2.1-1. Location and Acreage of Known Geothermal Resource Areas (KGRA's)



XBL806-1295

Source: California Division of Mineral Geology, and R. Christiansen, USGS, Menlo Park.

Geothermal resources in California occur in lands that are administered by a number of federal, state, and private entities. Sections 2.11, 2.12, and 2.13 describe the different land use regimes relevant to present exploration, leasing, and drilling activities. Each discussion is followed by a brief description of activities at specific sites.

2.11 EXPLORATION

The permitting process for these activities is different for federal, state, and private lands. Exploration activities include geology, geophysics, geochemistry, temperature gradient drilling, and other activities.

FEDERAL LANDS

Exploration on federal lands in California is controlled by the appropriate land management agency (LMA). The two largest are the U.S. Forest Service (USFS), which has jurisdiction over designated national forests, and the Bureau of Land Management (BLM), acting as caretaker of most federal lands not designated as national forests. A number of other federal agencies act as land managers, but of less acreage. However, some of these agencies do control lands with significant geothermal potential. Among them are the Water and Power Resources Service (WPRS), at East Mesa; the National Park Service, at Mt. Lassen National Park; and the Department of Defense, at Coso Hot Springs.* Before exploration can begin, the exploration firm must file a Notice of Intent (NOI) with the appropriate LMA. Exploration activities are authorized under a Plan of Operation (POO) approved by the LMA.** The LMA has thirty days to approve or disapprove the permit to explore. Upon completion of exploration, the developer must file a Notice of Completion with the LMA.

Under separate Memoranda of Understanding, BLM has agreed to handle all requests for NOIs on both WPRS and USFS land.[1] If, in investigating the proposed exploration activity, the activity comes under the category of "casual use" of the land, the BLM may choose to allow exploration without the issuance of a formal NOI. This is often the case with geological and geochemical activities, and most geophysical surveys, where there is no noticeable disturbance to the land. However, most drilling activities, temperature gradient (TG) surveys, etc., require the NOI.

For lands under USFS jurisdiction, an Environmental Assessment Review is required prior to issuance of permits

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* See reference 9 for a more detailed outline of permitting on federal lands. The Water and Power Resources Service was formerly called the Bureau of Reclamation.

** Many tracts of land are leased before any exploration work is initiated to protect proprietary rights. It is also interesting to note that acquiring a lease to a piece of federal land does not prohibit the LMA from issuing permission to others to explore that property, even if there are producing geothermal wells located there.

for any exploration or leasing activities. At present there are no NOIs in effect on USFS lands in California, but the USFS is in the process of evaluating lands in Toiyabe, Inyo, and Lassen National Forest areas for possible geothermal use.

The BLM monitors exploration activities through its six regional offices in California. Current exploration activity, evidenced by NOIs presently in effect, is heaviest in the areas with proven geothermal potential, such as The Geysers and Imperial Valley. The following is a summary of exploration activities by region as of December 1979.* This summary is not meant to be comprehensive, but only to identify the type of activity that is undertaken in these areas. For current information the sources referenced in this section should be consulted.

- The Geysers Region

Phillips Petroleum is drilling temperature gradient holes in Mendocino, Sonoma, and Lake counties. Occidental Geothermal is completing a seismic survey and some test drilling in Lake and Sonoma counties. Aminoil USA has just completed a program in the Knoxville KGRA. Amax Exploration has also been active in the Mount St. Helena area, mainly on private lands.[2]

- Imperial Valley

In Imperial County, the USGS has been conducting temperature gradient drilling in an effort to study the large scale crustal features in this area. Phillips Petroleum has made extensive studies in San Bernadino County, in Imperial County near West Mesa, and in the Chocolate Mountain area. Occidental Geothermal has drilled temperature gradient holes in the Glamis KGRA and at East Mesa. Exploration interest in the future is expected to center in the Glamis and Dunes KGRAs along the west side of the Imperial Valley, and in the Randsburg KGRA.[3]

- Northern California

Geotronix, Inc., a geophysical contractor, is conducting a magnetotelluric survey in Surprise Valley.[4] There has been some interest in the Fall River area but no formal permitting has taken place.[5]

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* Section 7.1 provides an update of recent exploration activities.

• Central California

In the central portion of the state, the USGS is drilling a limited number of temperature gradient holes in selected locations stretching from northwest of Bakersfield to the Death Valley-Mojave areas. The WPRS has recently drilled TG holes in the Bridgeport areas, and Phillips Petroleum has TG holes proposed for an area near Mono Lake.[6]

STATE LANDS

The State Lands Commission (SLC) may issue prospecting permits giving the permittee exclusive right for two years to prospect for geothermal resources.[7] Under the terms of this type of permit, if a discovery of commercial quantities of geothermal resources is made, the permittee is entitled to a lease from the commission provided the terms for such a lease are stated in the permit.

The SLC may also grant nonexclusive geological or geophysical exploration permits for exploration of geothermal resources. This type of permit does not give the permittee any preferential right to a geothermal lease.

State law also places a minimum parcel size, for both prospecting and leasing, of 640 acres and a maximum size of 5760 acres. No more than 25,600 acres may be permitted or leased by a single entity at one time.[7]

At the present time, the SLC has only a limited number of exploration permits in effect, mostly in The Geysers and Imperial County areas.* A listing of geothermal exploration permits is presented in Table 2.11-1.

PRIVATE LANDS

Geothermal geophysical exploration on private lands is regulated by local government agencies, usually at the county level.** Records of such activities, if required at all, are kept at the local level. The California Division of Oil and Gas does monitor geothermal drilling activities on private and state lands. Other than this, there is no state entity which monitors geothermal geophysical exploration activities on private lands.

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* Because the extent of state land ownership in California has not yet been resolved, an estimate of geothermal potential underlying state lands is not yet possible.[10]

** See reference 8, Workshop #1, County Planning for Geothermal Development, December 1978.

Table 2.11-1. Permits to Prospect for Geothermal Resources

PRC	Permittee	County	Acreage	Expiration Date
2548.1 T	R. W. Cypher	Imperial	40	7-4-63
2705.1 T	R. W. Cypher(conv.into Lease PRC 3143.1)	Imperial	55	5-28-64
2706.1 T	R. W. Cypher(conv.into Lease PRC 3144.1)	Imperial	160	5-28-64
2707.1 T	R. W. Cypher(conv.into Lease PRC 3145.1)	Imperial	160	5-28-64
2708.1 T	R. W. Cypher(conv.into Lease PRC 3146.1)	Imperial	160	5-28-64
2862.1 T	R. W. Cypher	Imperial	160	5-28-64
2863.1 T	R. W. Cypher	Imperial	160	6-3-65
2864.1 T	R. W. Cypher	Imperial	160	6-3-65
2865.1 T	R. W. Cypher	Imperial	160	6-3-65
2866.1 T	R. W. Cypher	Imperial	160	6-3-65
2867.1 T	R. W. Cypher	Imperial	160	6-3-65
3036.1 T	O'Neill, et al.	Imperial	40	6-3-65
3088.1 T	Imperial Thermal Products	Imperial	80	3-17-67
3395.2 T	Union(conv.into Lease PRC 4596.2)	Sonoma & Lake	160	5-27-71
3396.2 T	Union(conv.into Lease PRC 4596.2)	Sonoma	181.86	5-27-71
3472.2 T	Union(consolidated w/3396.2)	Sonoma	418.57	6-26-69
3473.2 T	Union(consolidated w/3395.2)	Sonoma & Lake	1463	6-26-69
3480.2 T	Union	Lake & Medocino	1040	7-20-71
3496.2 T	Signal	Lake	440	7-18-71
3520.2 T	Cordero, Geoth. Elec. Corp.	Sonoma	40	11-28-71
3521.2 T	Cordero, Geoth. Elec. Corp.	Mendocino	27.79	2-16-72
3522.2 T	Cordero, Geoth. Elec. Corp.	Sonoma	40	2-16-72
3523.2 T	Union	Sonoma	80	9-21-71
3708.2 T	Signal	Medocino	160	3-20-72
3828.2 T	Signal	Sonoma	868.24	5-24-73
3829.2 T	Signal	Sonoma	40	5-24-73
3830.2 T	Signal	Sonoma	434.16	5-24-73
3831.2 T	Signal	Sonoma & Mendocino	440	5-24-73
3832.2 T	Signal	Mendocino	160	5-24-73
4236.2 T	Union(conv.into Lease PRC 4597.2)	Sonoma & Lake	1284.65	5-26-71
4336.2 T	Cordero, Geoth. Elec. Corp.	Mendocino	1480	10-1-74
4337.2 T	Cordero, Geoth. Elec. Corp.	Mendocino	200	10-1-74
4338.2 T	Cordero, Geoth. Elec. Corp.	Mendocino	40.04	10-1-74
4339.2 T	Union(conv.into Lease PRC 4596.2)	Lake	320	5-27-71
4340.2 T	Union(conv.into Lease PRC 4597.2)	Lake & Sonoma	160.22	5-27-71
4341.2 T	Union	Lake	120	10-1-74
4364.2 T	Cordero, Geoth. Elec. Corp.	Mendocino	360	11-13-74
4365.2 T	Cordero, Geoth. Elec. Corp.	Mendocino	440	11-13-74
4366.2 T	Cordero, Geoth. Elec. Corp.	Lake	120	11-13-74
4367.2 T	Cordero, Geoth. Elec. Corp.	Lake	40	11-13-74
4368.2 T	Cordero, Geoth. Elec. Corp.	Sonoma	200	11-13-74
4369.2 T	Cordero, Geoth. Elec. Corp.	Lake & Mendocino	292.75	11-13-74
4370.2 T	Cordero, Geoth. Elec. Corp.	Sonoma	200	11-13-74
4371.2 T	Glebe	Lake	600	11-13-74
4372.2 T	Seghesio	Mendocino	160	11-13-74
4373.2 T	Signal	Sonoma	80	11-13-74
4395.2 T	Forbes, et al.	Lake	760	1-6-75
4396.2 T	Forbes	Lake	400	1-6-75
4397.1 Q	Geoth. Resources Int.	Mono	4773.94	1-6-72
4398.1 Q	Geoth. Resources Int.	Mono	2166.90	1-6-72
4399.1 Q	Geoth. Resources Int.	Mono	1750.65	1-6-72
4400.1 Q	Geoth. Resources Int.	Mono	2245.45	1-6-72
4401.1 Q	Geoth. Resources Int.	Mono	5275.51	1-6-72
4571.1 Q	So. California Edison Company	Mono	4710	2-29-72
4572.1 Q	So. California Edison Company	Mono	4728	2-29-72
4573.1 Q	So. California Edison Company	Mono	3226	2-29-72
4574.1 Q	So. California Edison Company	Mono	4877	2-29-72
4575.1 Q	So. California Edison Company	Mono	4813	2-29-72
4576.1 Q	So. California Edison Company	Mono	2720	2-29-72
4577.2 Q	So. California Edison Company	Mono	240	2-29-72
4700.1 T	Atlantic Oil Co.	Imperial	1854	8-30-75
4701.1 T	Atlantic Oil Co.	Imperial	2039	8-30-75
4739.1 Q	American Thermal Resources	Modoc	640	8-30-75
4740.1 Q	American Thermal Resources	Modoc	360	3-28-76
4802.1 T	Getty - Mono Power Co.	Inyo	3332	8-29-76
4803.1 T	Getty - Mono Power Co.	Inyo	5646	8-29-76
4804.1 T	Getty - Mono Power Co.	Inyo	5760	8-29-76
4863.1 Q	Gulf	Lassen	640	1-30-77
4906.1 T	American Thermal Resources	Modoc	4270	4-24-77
4927.1 T	American Thermal Resources	Modoc	3828	6-26-77
4928.1	Getty Oil Company	Modoc	5427	6-26-77
4929.1	Getty Oil Company	Modoc	4430	6-26-77
4957.1 Q	Gulf Oil Corporation	Modoc	5150	6-19-75
4958.1 Q	Gulf Oil Corporation	Modoc	5620	6-19-75
4959.1 Q	Gulf Oil Corporation	Modoc	3508	6-19-75
5147.2	Aminoil	Sonoma	200	6-28-79
5165.2	Q. B. Resources International	Imperial	640	7-21-79
5412.2	Geothermal Kinetics Inc.	Lake	1785	

T-Terminated
Q-Quitclaimed

Source: California State Lands Commission

REFERENCES

1. Jack Lahr, BLM Sacramento, May 1979: Communication.

2. Stan McKee, BLM Ukiah, May 1979: Communication.

3. Roger Haskins, BLM Riverside, May 1979: Communication.

4. Tim Carrol, BLM Susanville, May 1979: Communication.

5. Terry Woolsey, BLM Redding, May 1979: Communication.

6. Warren Longwell, BLM Bakersfield: Communication.

7. California Senate Bill No. 1027, 1978.

8. State of California, Geothermal Resources Board, Final Report on Four Workshops, December 1978-March 1979.

9. Science Applications Inc., Institutional and Financial Profile for Geothermal Energy in California and Hawaii (Draft Review), October 1978.

10. Don Hoagland, SLC October 1979: Communication

2.12 LEASING ACTIVITIES

This section describes the leasing procedures and environmental review requirements imposed by the various governmental agencies with authority over geothermal lands in California. It also summarizes the leasing and drilling activities undertaken to date under each of these regimes. Table 2.12-1 shows the location of major activities, the date of lease sales, and the number of acres leased.

Table 2.12-1. Federal Geothermal Lease Sales in California, 1974-1979

KGRA	Date of Sale	Lessee	Acres
Lake City/Surprise Valley	6/23/75	Getty Oil	5913.8
		Dow Chemical	2083.4
		Southern Union Production Co.	2586.5
Wendel-Amadee	9/21/78	Robert Elliot	1205.2
The Geysers	1/22/74	Shell Oil	3474.0
		Thermogenics	175.0
		Union Oil	3337.0
		Signal Oil	987.0
		Occidental Petroleum	382.0
	5/29/74	Natomas	625.0
		Union Oil	160.0
	9/14/77	Shell Oil	2857.0
	11/22/78	State of California	470.7
		Union/Magma/THL	2171.0
		Occidental	548.9
Mono-Long Valley	1/22/74	Chevron Oil	1815.1
		Getty/Mono	1895.2
		Republic Geothermal	1772.7
East Mesa	1/22/74	Magma Power	5064.7
		Republic Geothermal	4145.3
	6/4/74	Republic Geothermal	2560.0
	5/10/79	Republic Geothermal	5039.0
		Union Oil	1929.0
			50,811.4

Source: U.S. Geological Survey, Conservation Division, Office of the Deputy Conservation Manager for Geothermal, Bidding History of Competitive Geothermal Lease Sales on Federal Land.

Other tables within this section provide more detailed information to support site-specific descriptions of recent activities. Because there is virtually no delay for leasing on privately held lands, these lands have received the greatest interest to date. Activities are also expanding on state and federal lands, as environmental reviews are completed and priorities are established.

As with exploration activities, each of the entities controlling the development of geothermal lands in California - the federal and state governments, and private landholders - follows slightly different procedures in leasing properties for geothermal exploitation.

FEDERAL LANDS

After an area has been evaluated by the land management agency (LMA)* and the decision made to lease the land for geothermal development, either competitive or non-competitive bidding may be authorized.** Applications for non-competitive leases (on federal lands outside KGRAs) are submitted and accumulated over a one-month period. At the close of this period the requested lease area is again reviewed for KGRA or existing lease infringement. (Overlapping bids automatically designate an area as a KGRA.) A lead agency is then designated for the Environmental Assessment Report (EAR). Based on the findings of the EAR, an Environmental Impact Statement (EIS) may be required. If a favorable decision is rendered following the environmental review by the LMA, a bid for the lease is then submitted by the developer to the LMA. The LMA, after determining whether the bid is acceptable, may award a lease to the developer. Leases are generally awarded for a period of 10 years and may be renegotiated with the LMA at the end of that period.***

The area is then reviewed once more by the LMA for infringement on a KGRA. After the final certification as a non-KGRA, the lease is issued.

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* The Bureau of Land Management and the U.S. Forest Service are the principal LMAs in California. The Water and Power Resources Service and Department of Defense also have some holdings. (See Section 2.11, supra.)

**A minimum parcel size of 640 acres is usually required, unless the LMA determines that special considerations warrant a smaller size.

*** New federal legislation may extend the lease period to twenty years. (See Section 7.3)

In the *competitive* scheme, the bidding procedure has more formalized constraints for both the bidder and the LMA. Competitive bidding, by definition, is always required on federal lands that have been designated KGRAs. Part of the leasing program developed by the land agency includes budgeting and scheduling of an EAR (usually one to three years), and preparation of a leasing schedule. The lead agency usually prepares the EAR (7 to 12 months), and normally conducts this investigation following the format of an EIS to save time in case the latter document is required. Once completed, the EAR is distributed to various state, federal, and local agencies and to the general public for formal comment (comment and revision can take 8 to 12 months). Following approval of the EAR, the leases are announced and bids are submitted. An EAR is prepared for lands designated as KGRA. An EIS is prepared if there is concern that the leasing action will lead to a significant impact on the human environment. At this point the LMA decides whether or not to continue with the leasing procedure. If the decision is to continue, a lease sale is scheduled. The LMA is charged with conducting the lease sale, but the responsibility for determining a fair market value for the land is delegated to the USGS, which, beginning with the EAR, becomes responsible as the technical representative for the LMA.

The LMA is responsible for issuing mineral leases and licenses and is the office of record for leasing matters. The USGS is responsible for all geologic, engineering, economic value determinations, and supervision of lessee operations. These responsibilities include parcelling of leasing tracts, determining land values, establishing royalty and rental rates, evaluating resources, and calculating reserves. Also included are reviewing investment costs for diligent development and minimum production requirements and generally supervising the area of operations within a lease. (See reference 7 for further detail.)

The LMA then schedules and conducts the lease sale. Thirty days after the sale, the LMA must make a decision to award a lease to the highest bidder, or, if the bidding does not meet the minimum criteria established by the USGS, deny the bidders a leasing agreement and return the land to a pre-lease status. If a lease is awarded, the lessee is notified and is expected to execute the lease within the next month (this usually includes submitting the bonus bid and a plan of operation for drilling). The lessee usually has a specified amount of time to utilize the[8] resource, after which time the lease comes up for renewal.

Table 2.12-1 lists by region the federal lease sales which have been held in California during 1974-1979.* Two factors have inhibited leasing of federal lands. First, because of the formalities involved, competitive bidding is much more time consuming than the non-competitive process, and often more costly to the developer. As a result, a significant number of lands which have been designated as KGRAs in California have not been seriously explored for their geothermal potential. Second, because of the limited resources of the LMAs, it has been necessary to establish priorities for evaluating these agencies' lands. This means some lands will not be available for leasing until the LMA has been available for leasing until the LMA involved has apportioned the resources to gather and evaluate the required pre-leasing data.**

STATE LANDS

In California, the State Lands Commission (SLC) is authorized to grant permits and leases for exploration and development of geothermal resources on lands owned by the state, and on lands for which the geothermal resources have been reserved for the state (i.e., Homestead Act mineral reserve lands).[1] The SLC also has discretion to designate a piece of land for competitive or non-competitive bidding.*** The minimum parcel size is generally 640 acres if the parcel is intended for electricity development. If a parcel is less than 640 acres in size, or if the parcel is intended for non-electrical applications, a lease may be issued for less than 640 acres. Leases can be granted for as long as 99 years, but the recent practice of the SLC has been to issue them for 20 years. Table 2.12-2 lists the number of active leases on state lands.

Lands designated for competitive leasing are bid upon on the basis of cash bonus, net profit, or some other single biddable factor. This procedure differs somewhat from the federal one in that it allows the SLC to accept bids on the basis of a percentage of the net profits of the developer. This arrangement seems to give the bidder more flexibility by minimizing front-end costs and permits smaller

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* For a complete listing of federal lease sales see Cumulative Statistical Bid Recap, Federal Geothermal Sales, 1974-1978, available from the USGS. State lease sales records are presented in Table 2.12-2.

** See reference 6 for a discussion of baseline date acquisition and land ownership patterns and their effects.

*** See California Public Resources Code, sections 6904, 6910, 6912 1, for further detail.

Table 2.12-2. Active Leases on State Lands in California

County	Expiration	Lessee	Acres
Imperial	5/27/84	New Albion Resources - Thermal Magma	535.0
Lake & Sonoma	5/26/91	Union Oil	3,988.3
	12/13/96	Natomas	130.0
	2/24/97	Wildhouse Ranch	434.0
			5,087.3

Source: State Lands Commission, Geothermal Resources Program - A Dynamic Approach to Alternative Energy Development, July 1977.

independent developers to participate. The procedure has allowed the state to realize profits that will be significantly larger on a per-acre basis than those received by the federal government. However, the pay-back time is significantly longer.[2]

The California Division of Oil and Gas (DOG) has the statutory responsibility for preparing environmental documents for geothermal exploratory projects on state and private lands.* DOG may delegate this responsibility to a county that has adopted a geothermal element to its general plan.** Imperial County is presently the only county to which DOG has delegated this responsibility.[3] DOG, or its representative, must complete this evaluation within 135 days of notification. The cost of the document is to be borne by the developer.

PRIVATE LANDS

The various counties of California, usually through a planning commission, have the authority to determine the types of uses permitted on private land. In general, exploration and leasing arrangements are negotiated on an individual basis with landowners who have retained their mineral rights. Because of the relatively simple leasing procedures involved, much of the private land with

* See the California Environmental Quality Act of 1970 and Section 3715.5 of the Public Resources Code.

** Authorized through AB 2644. See Section 5.24, infra, for a discussion.

identified geothermal potential in California has been leased.[4]

RECENT ACTIVITIES IN KGRAs

The following is a summary of information from Geothermal Leasing in California, State-Federal-Local Agency Task Group Working Paper, September 1978, with updates from Geothermal Program California, BLM April 1979. It is a synopsis of recent activities at The Geysers, Imperial Valley and the other geothermal areas in California which have been given the highest priority for development by Bureau of Land Management (BLM), the U.S. Geological Survey (USGS), the California Energy Commission, and the State Lands Commission.*

Figure 2-3 (p.22) Geothermal Development on Public Lands, illustrates the relationship among the environmental assessment efforts.

The Geysers KGRA

In The Geysers area, the state controls approximately 21,000 acres of reserved mineral lands with 4,522 acres under lease, and 1,900 acres under prospecting permits. The federal government owns 14,000 acres of mineral reserve and 11,150 acres of fee land. A 3,000-acre lease sale was held in February 1979 in which nine parcels of federal land were leased for $16 million.** Pre-lease resource inventories are being studied on a 4,000-acre block of mineral reserve land in The Geyser Peak Study area, south and west of the Geysers Resort.

Imperial Valley KGRAs

The Imperial Valley region includes six KGRAs: Salton Sea, Brawley, Heber, Glamis, Dunes, and East Mesa. At East Mesa, eight parcels (18,600 acres) were offered for sale in mid-1979. Five of these parcels had been offered at previous lease sales, and an additional three had been withdrawn previously for use by the Water and Power Resources Service geothermal test facility. Inventory studies of some 90,000 acres of non-competitive land at East Mesa are being undertaken. Lease sales for those areas between the Coachella and East Highline Canals were made in late 1979.

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* See Figure 2.1-1 for the location and acreage of various KGRAs.

** All parcels were on private land with mineral rights reseved to the federal government through the Stock Raising Homestead Act.

Some industry interest has been shown in the Glamis and Dunes KGRAs, but both areas contain significant environmental constraints and protective withdrawals.

In the Yuha area, 13 non-competitive applications covering 27,000 acres were considered in late 1979. At the North Salton Sea, five non-competitive leases, with no surface occupancy stipulations, have been awarded. Environmental review continues on these lease areas. At San Felipe Wash, at the southwest corner of the Salton Sea, four non-competitive applications for 8,800 acres have been filed. There may be potential environmental conflicts within the San Felipe Marsh, and the CSO Fisheries Biologist is reviewing the area.

Knoxville KGRA

Resource inventories and the EAR are in process on BLM lands. Leasing is scheduled for the summer of 1981. The present study area includes 147,000 acres in the KGRA. Non-competitive areas covering 23,000 acres will be studied later.

Coso KGRA

The U.S. Navy is the LMA in this area since it controls a large part of the KGRA for naval ordinance testing and development. The Navy has contracted with the California Energy Company to develop the Navy's geothermal resources and eventually to construct a power plant which will generate electricity for military requirements.

The BLM is preparing an environmental impact statement for leasing in this area. A contract has been awarded to Rockwell International for the resource inventory and pre-leasing EIS for 67,000 acres of the Coso KGRA and 5,120 acres of adjacent non-competitive lands. The draft EIS is scheduled to be released for public comment in February 1980, with a final decision date of December 1980 anticipated.* The outcome of the EIS will probably be influenced by the recent designation of Coso Hot Springs as a National Historic Register site.

In Rose Valley, the City of Burbank remains interested in developing a hybrid geothermal coal-fired power plant.[5]

Randsburg KGRA

The Randsburg KGRA encompasses 12,880 acres, of which approximately 90% are federal lands, with the remaining 10% held by the state. Surrounding the KGRA are some 73,000

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* See Section 7.1 for a status update.

acres of land to be considered for non-competitive leasing. The pre-lease environmental assessment has been completed, and four non-competitive leases were issued under "no surface occupancy" stipulations in September 1978.

A major portion of the KGRA and surrounding area have been withdrawn from leasing consideration and designated as Wilderness Study Areas.* A portion of the KGRA and some of the non-competitive areas have been, opened but the general opinion of industry is that the amount of land that is presently available is inadequate for development.[5]

The state of California has issued prospecting permits for its land. In one case, however, the property is completely surrounded by federal lands.[6] In this instance, exploration and development will probably be minimal until the leasing status of the federal lands is settled.

Mono-Long Valley KGRA

The land in the Mono-Long Valley KGRA is divided among the U.S. Forest Service (approximately 290,000 acres), the Bureau of Land Management (approximately 205,000 acres), and state and private lands (65,000 acres). The USFS has recently completed a forest management EIS which addresses geothermal development and is now working on the Mammoth Geothermal EAR.

Republic Geothermal completed an unsuccessful test well in the area and, as a result, industry interest for leasing the BLM lands east of this site has diminished significantly. However, the wellsite was not in the prime area of the prospect and this unsuccessful test does not preclude renewed exploration activities in the future. Mono County has approved the drilling of three exploratory wells on private lands, but it is not likely that they will be drilled before leases are offered on the adjacent USFS lands, since a discovery on the private properties would significantly increase the leasing costs on USFS lands.

Evaluation and development of the geothermal resource is expected to proceed slowly because of the close attention that must be given to wilderness issues, the present unavailability of the prime prospect areas for leasing (Wilderness Study Areas), and the further consideration to be given to wildlife issues and archeological areas.

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* Section 603 of the Federal Land Policy and Management Act of 1976 states that no management action be taken to degrade the wilderness potential of roadless areas of 500 acres or more.

Wendel-Amedee KGRA

One lease was issued in the competitive lease area in January 1979. One lease has been awarded on neighboring non-competitive lands, and two further applications are being considered for lands presently included in a Wilderness Study Area.

Surprise Valley KGRA

Three federal leases are presently in effect, and three others have been abandoned in the area. To date (December 1979) no commercial production ventures have been undertaken.

Beckwourth Peak KGRA

An EAR is being undertaken by the BLM/USFS. The lease sale is tentatively scheduled for February 1980.

Bridgeport (non-competitive area - in Mono county, north of Mono-Long Valley KGRA)

The resource potential of the area is under study by the Water and Power Resources Service and the California Division of Mines and Geology. The WPRS is undertaking a shallow drilling program to evaluate water quality and quantity. The BLM is studying the area for a grazing EIS. No leasing is scheduled, although 19 applications for 30,500 acres are on file.

NON-COMPETITIVE AREAS

Interest in leasing is increasing in non-competitive areas. An indication is the large number of applications received per area by both the BLM and the USFS in 1979.

BLM Non-Competitive Areas (Applications / Acres)

Pit River - northwest Lassen County (1 app./ 2,362 ac.)

Bristol-Amboy - San Bernardino County (48 app. / 106,000 ac.)

Timbered Crater - Shasta County, east of Redding (3 app. / 5,145 ac.)

Owens Valley - Inyo County (6 app. / 13,500 ac.)

Tecopa - Inyo County, east of Death Valley National Monument (7 app. / 11,760 ac.)

Saline Valley - Inyo County, east of Owens Valley (3 app. / 5,760 ac.)

Anza - Imperial County, southwest of El Centro (3 app. / 2,500 ac.)

U.S. Forest Service Non-Competitive Areas (Applications / Acres)

Glass Mountain - Siskiyou County (99 app. / 201,841 ac.)

Bend - Shasta County, south of Mt. Shasta (15 app. / 28,889 ac.)

Lassen - Lassen County, outside Lassen National Park (23 app. / 41,612 ac.)

Haden Hill - northwest Lassen County (4 app. / 6,879 ac.)

Eagle Lake - Lassen County, northeast of Susanville (10 app. / 23,769 ac.)

Crowley Lake - Mono County, south of Mono-Long Valley KGRA (10 app. / 22,868 ac.)

REFERENCES

1. California, Senate Bill No. 1027, 1978.

2. California State Lands Commission, Geothermal Resources Program, A Dynamic Approach to Alternative Energy Development, July 1977.

3. Doug Stockton, DOG, May 1979: Communications.

4. Chuck Priddy, SLC, April 1979: Communications.

5. BLM, Geothermal Program California, April 1979.

6. State-federal-local Agency Task Group paper, Geothermal Leasing in California, September 11, 1978.

7. R. T. Stone, H. L. Collins and M. D. Crittenden, The Role of the U.S. Geological Survey in the Federal Geothermal Leasing Program (Draft), USGS, Menlo Park, California, 1979.

8. Systems Development Corporation, Regional Systems Development for Geothermal Energy Resources, Pacific Region (California and Hawaii), TM-(2)-6050/021/01.

2.13 GEOTHERMAL DRILLING

For statistical purposes, geothermal drilling in California has been subdivided into four general categories: temperature gradient, exploratory, production, and injection wells. The California Division of Oil and Gas (DOG) uses somewhat different terminology in its classifications of geothermal wells, but the four kinds of wells are equivalent (see the data at the end of this section).

A temperature gradient hole is a shallow hole, generally two to three hundred feet in depth, used to measure the flow of heat near the surface at a particular site. An exploratory well is essentially a "wildcat well," an attempt to prove a producing zone by actually drilling into the reservoir. If successful, it can be used as a production or injection well. A production well, as the name implies, is a viable well producing for either electricity generation or direct uses. An injection well is used for returning the spent geothermal fluid to the subsurface reservoir either for disposal or to recharge the system.

The California Division of Oil and Gas (DOG) has the responsibility for regulating and monitoring all geothermal wells drilled in California, with the single exception of those wells drilled on federal lands by U.S. government drilling crews.* However, developers drilling on leased federal land still must file drilling records, etc.**, with the DOG. The DOG also coordinates with the federal government to obtain data on federal wells so that the DOG statistics are complete.

DOG has established three geothermal districts (Figure 2.13-1) through which all drilling activities are monitored.

The "Index of Geothermal Well Records" is a listing of each well drilled in the state. Some of this information is proprietary (e.g., wells drilled by private industry), and is available for public scrutiny only after the confidentiality period has expired. The confidentiality period is normally 5 years and may be extended for an additional 2 years or longer at the request of the operator by the Director of the Department of Conservation after a public

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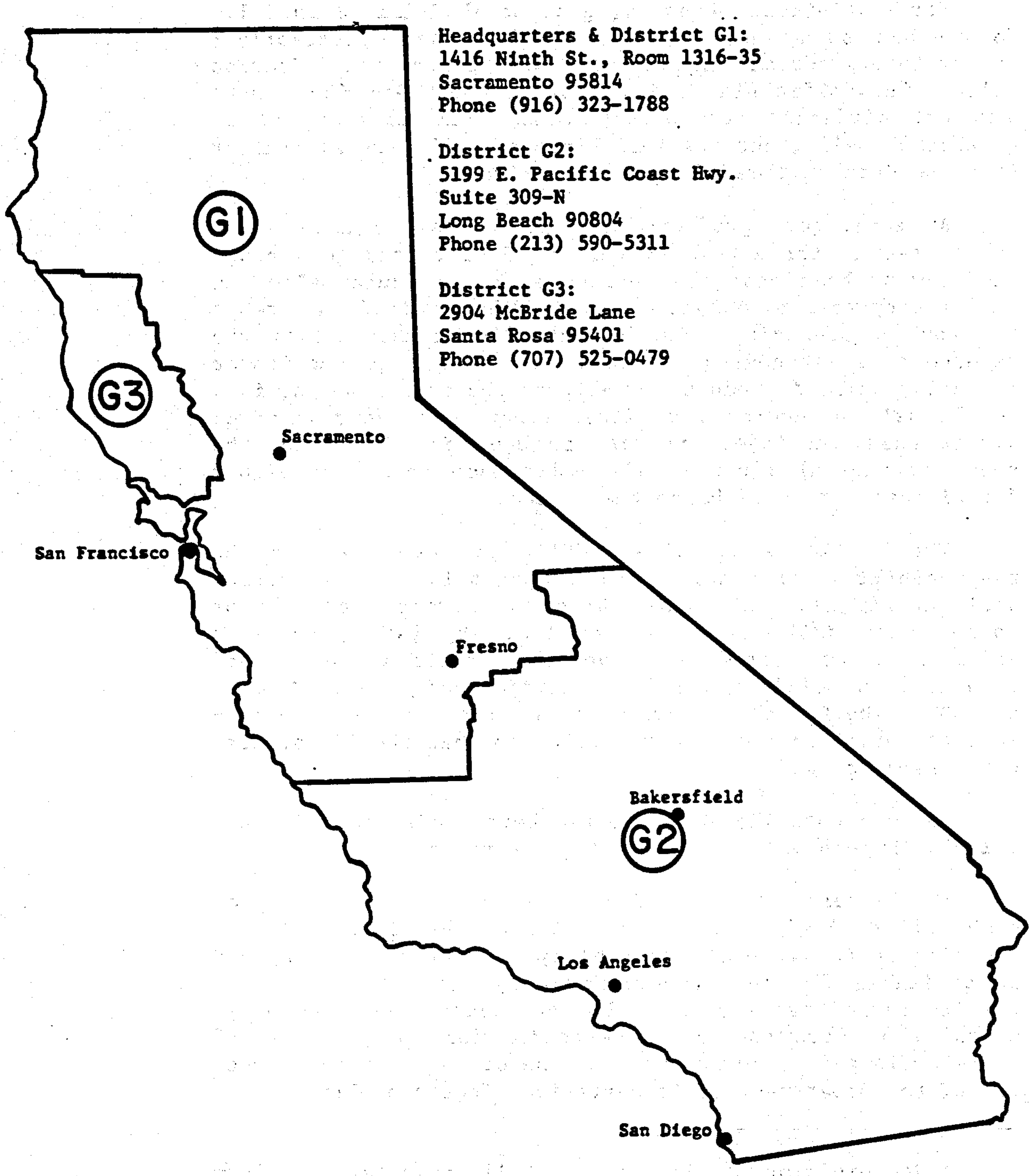
* See Division of Oil and Gas, California Laws for Conservation of Geothermal Resources, PRC 02 (6-79-DWRR-3C), 1979. The USGS also has responsibility for actions relating to supervision of the area of operations within a federal lease.

** See Figure 2.13-1 for a map of DOG's district boundaries and district offices.

Figure 2.13-1. Geothermal District Boundaries and District Offices



Headquarters & District G1:
1416 Ninth St., Room 1316-35
Sacramento 95814
Phone (916) 323-1788

District G2:
5199 E. Pacific Coast Hwy.
Suite 309-N
Long Beach 90804
Phone (213) 590-5311

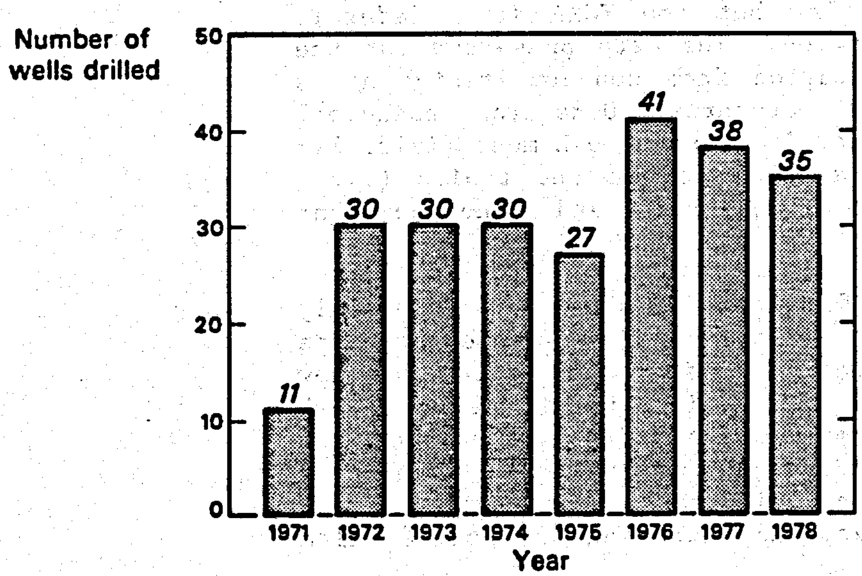
District G3:
2904 McBride Lane
Santa Rosa 95401
Phone (707) 525-0479

Source: California Division of Oil and Gas.

hearing.* DOG also produces a set of localized, detailed, maps of each area in which geothermal drilling is proceeding. These maps are updated weekly through DOG "Weekly Map Revision Bulletin, PR-55." DOG also publishes a list of "Notices Received to Drill, Rework, and Abandon (wells) Bulletin, PR-45."

A cumulative summary of geothermal wells drilled in California during the years 1971 to 1978 is presented in Figure 2.13-2.

Figure 2.13-2. Cumulative New Geothermal Wells Drilled in California 1971-1978



Sources: Division of Oil and Gas, California Department of Conservation, Summary of Operations - Oil, Gas, and Geothermal Production Statistics, Vol. 57, 59; 1971-1973. Division of Oil and Gas, Annual Report of the State Oil and Gas Supervisor, 1974-1977.

* See Sec. 3752 of Public Resources Code.

The data presented in Table 2.13-1 has been condensed and retabulated from data published in the DOG Annual Report series.

Drilling information in the tables includes data on geothermal production wells, injection wells, and exploration wells. Information on observation (temperature-gradient) holes is not included because this type of drilling is used for exploration purposes, and because obervation holes cannot be used as "producing" wells even if geothermal fluids are encountered. A distinction is made in the table between "Fields" and "Counties." A field contains at least one well capable of producing geothermal resources in commercial quantities. The boundaries are established by graphically constructing one-mile squares around each of the wells. A field, e.g., The Geysers, usually involves competitive leasing. (See Section 2.12) KGRA and "field" boundaries generally overlap but the KGRA is a federal, rather than state, designation. The data presented for the "counties" is that information from non-competitive areas not included in the "field" boundaries. Data from geothermal fields is tablulated separately, even though most fields lie within counties that are also listed in the tables (e.g., The Geysers field lies in Lake, Sonoma, and Mendocino Counties.)

Reading the data from the tables is relatively straightforward. For example, in looking at The Geysers data from 1971, one can see that 13 notices were filed for new wells, and two additional applications were made to rework older wells. Eleven new wells were drilled, of which ten were completed to production. One new well was abandoned. Additionally, one notice was filed to abandon a well previously listed as a producer, and there was one notice filed to abandon a dry hole.

The category "new wells (drilled)" includes geothermal producing wells, injection wells, and exploration wells, so that all the new wells drilled would not be expected to be completed to production. For example, only 13 of the new wells drilled in 1972 were completed to production, and 4 abandoned. It is assumed that drilling on the remaining 13 wells was still in progress, or that the wells were at least not formally abandoned.

Finally, most of the names of California's "field" designations correspond to the names of the federal KGRAs. An exception, however, is the Casa Diablo field, which refers to the Mono-Long Valley area.

Table 2.13-1. Geothermal Operations, 1971-78

Field or County	New Wells			Notices Filed			
	Drilled	Completed to Productions	Abandoned	New Wells	Reworks	Abandonment	
						Producers	Dry holes
1971							
Casa Diablo	0	0	0	0	0	1	0
The Geysers	11	10	1	13	2	1	1
Salton Sea	0	0	0	1	0	0	0
State totals	11	10	1	14	2	2	1
1972							
Field			Within Geothermal Field				
Casa Diablo	0	0	0	0	0	0	0
The Geysers	15	13	0	22	7	0	0
Salton Sea	5	0	0	4	0	0	0
County			Outside Geothermal Fields				
Imperial Co.	7	0	2	7	0	0	2
Lake Co.	1	0	1	1	2	0	2
Lassen Co.	0	0	0	1	0	0	0
Mendocino Co.	1	0	1	1	0	0	1
Modoc Co.	1	0	0	1	0	0	0
State totals	30	13	4	37	9	0	5
1973			Within Geothermal Fields				
Field							
Casa Diablo	0	0	0	0	0	0	0
The Geysers	19	15	0	22	8	1	1
Salton Sea	0	0	0	0	2	0	0
County			Outside Geothermal Fields				
Imperial Co.	5	1	0	4	2	0	0
Lake Co.	1	0	0	0	1	0	1
Lassen Co.	2	0	1	2	0	0	1
Modoc Co.	2	0	1	2	0	0	1
Dulmas Co.	1	0	1	1	0	0	0
State totals	30	16	3	31	13	1	4
1974							
Field			Within Geothermal Fields				
Casa Diablo	0	0	0	0	0	2	0
The Geysers	21	18	2	21	7	2	3
Salton Sea	1	1	0	1	0	0	0
County			Outside Geothermal Fields				
Imperial Co.	6	6	0	7	0	0	0
Lake Co.	0	0	0	2	0	0	0
Mendocino Co.	0	0	0	3	0	0	0
Modoc Co.	2	0	1	2	1	0	1
Plumas Co.	0	0	0	0	0	0	1
Sonoma Co.	0	0	0	1	0	0	1
State totals	30	25	3	37	12	2	5

Table 2.13-1 continued

Field or County	New Wells: Drilled	New Wells: Completed to Production	New Wells: Abandoned	Notices Filed: New Wells	Notices Filed: Reworks	Notices Filed: Abandonment: Producers	Notices Filed: Abandonment: Dry holes
1977							
Field		Within Geothermal Fields					
Casa Diablo	0	0	0	0	0	0	0
The Geysers	21	17	2	24	14	0	1
Lake City	0	0	0	0	0	0	0
Salton Sea	0	0	0	0	0	3	0
County		Outside Geothermal Fields					
Imperial Co.	9	8	0	2	6	0	1
Lake Co.	6	0	0	5	0	0	0
Lassen Co.	0	0	0	0	0	0	0
Mendocino Co.	0	0	0	0	0	0	0
Napa Co.	0	0	3	0	0	0	0
San Bernardino Co.	0	0	0	0	0	0	0
Sonoma Co.	2	1	1	2	0	0	0
State totals	38	26	3	33	20	3	2
1978		Within Geothermal Fields					
Field							
Brawley	4	0	0	6	2	0	0
Casa Diablo	0	0	0	1	0	0	0
East Mesa	6	6	0	0	0	0	0
The Geysers	17	12	2	9	3	0	0
Heber	0	0	0	0	0	0	0
Lake City	0	0	0	0	0	0	0
Salton Sea	0	0	0	0	0	0	0
Counties		Outside Geothermal Fields					
Imperial Co.	2	2	0	6	0	0	0
Lake Co.	3	0	0	12	1	0	0
Lassen Co.	-	-	-	0	0	0	0
Mendocino Co.	0	0	0	0	0	0	0
Mono Co.	-	-	-	1	0	0	0
Napa Co.	1	0	0	1	0	0	0
Plumas Co.	0	0	0	0	1	0	0
Riverside Co.	0	0	0	0	0	0	0
San Bernardino Co.	0	0	0	0	0	0	0
Sonoma Co.	2	0	0	1	0	0	0
Stata totals	35	20	2	37	7	0	0

Sources: Division of Oil and Gas, California Department of Conservation, Summary of Operations - Oil, Gas, and Geothermal Production Statistics, Vol. 57, 59; 1971-1973. Division of Oil and Gas, Annual Report of the State Oil and Gas Supervisor, 1974-1977. Communications with Doug Stockton, Division of Oil and Gas, 1979.

2.2 DESCRIPTION OF SIGNIFICANT DEVELOPMENT ACTIVITIES

HISTORY OF GEOTHERMAL DEVELOPMENT

"...the great economic success of geothermal power has been clearly demonstrated by the three ´geothermal giants´ - Italy, New Zealand and California..." --Christopher H. Armstead[1]

It is interesting to examine the history of modern geothermal development to gain an understanding of California´s contributions to this industry. Geothermal electrical power had its birth in the early 1900´s in Larderello, Italy, where, after 10 years of experimentation and process design, the first geothermal power plant began producing electricity in 1913. Larderello remained the largest geothermal field in the world for 50 years until The Geysers steam field surpassed it in total power output in the 1960´s. New Zealand initiated development of the Wairakei field on the North Island in the early 1950´s, with the first power production coming on-line in 1958. The need for a submarine transmission cable for the transmission of electric power from the South Island to the North Island slowed further geothermal development in New Zealand, but the 1973 oil crisis renewed interest and spurred development of a new area at Broadlands, on the North Island.

The potential for geothermal power production in The Geysers area of California was recognized early in the century, but a serious effort to assess and harness this potential was slow to materialize. The first production wells at The Geysers field were drilled and a small amount of electricity generated in the mid 1920´s. Present day development is traced to the mid 1950´s when Magma Power Co. began drilling in the area. Electric power production began in 1960 with the commission of Geysers 1, a 12 MWe generating plant. Interest in geothermal energy has spread to a number of other areas in California, e.g., the Imperial Valley, Mono-Long Valley, Lassen, Coso, Wendel-Amedee, and Susanville.*

Direct Use

Low temperature applications for geothermal water, principally for spas and small-scale domestic heating, have been employed since ancient times in many parts of the world. Today France, Hungary, Iceland, Italy, Japan, New Zealand, and the eastern USSR have large-scale direct geothermal applications in the residential, commercial, and

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* See Section 1 for a list of areas with identified geothermal power potential.

industrial sectors.*

Several areas in the United States have utilized low temperature geothermal energy on a significant scale. Before the turn of the century, residential areas in Klamath Falls, Oregon, and in Boise, Idaho, were using geothermal waters for space heating. But the scale of these developments, even in relation to their parent communities, was not as significant as that in Iceland and a number of other countries.

In the early 1800's, Spanish explorers noted the presence of hot springs during their forays into California in search of possible mission locations. The earliest recorded inhabitants of The Geysers area, the Pomos and Mayacamas Indians, also noted the presence of geothermal waters by naming the area around the springs "the oven place."**

CALIFORNIA DEVELOPMENT PERSPECTIVE

Table 2.2-1 summarizes worldwide power production from steam- and liquid-dominated resources.

While the United States is a leader in power production from steam-dominated resources, it lags behind many countries with respect to liquid-dominated hydrothermal resources.

Direct use of geothermal energy in California has been restricted largely to small commercial operations. Typical of these activities are spas, small-scale greenhouse

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*Large-scale development of low temperature applications had its beginning in Iceland in the early 1900's. After a pilot district heating project had been designed and tested in the early 1930's in Reykjavik, a full-scale project was launched in 1933, and by 1975 virtually all the buildings in Reykjavik were supplied with geothermal district heat, via the municipally operated and government subsidized district heating system. More than 50% of the population of Iceland now enjoys the benefits of geothermal heating for home and hot water uses.

**It was in The Geysers area that the first significant commercial development of geothermal waters took place in the U.S. In 1852, Sam Brannan settled in the area that he named "Calistoga" (a combination of the words <u>Cali</u>fornia and <u>Saratoga</u> Hot Springs, New York), and there purchased 2000 acres of land and invested an estimated $500,000 to build the Hot Springs Hotel, which opened in 1862. For more than a decade it hosted San Francisco's elite and reportedly was considered as a site by Leland Stanford for his new university.

Table 2.2-1. Comparison of Worldwide Power Output for Vapor- and Liquid-Dominated Geothermal Systems

Vapor-Dominated		Liquid-Dominated	
U.S.	668 MWe	Japan	200 MWe
Italy	490 MWe	Philippines	200 MWe
		New Zealand	190 MWe
		Mexico	150 MWe
		El Salvador	100 MWe
		Kenya	35 MWe
		Iceland	30 MWe
		U.S.	30 MWe

Source: James Kuwada, October 26, 1979.

operations, and some aquaculture. Although several large-scale district heating projects have been proposed, nothing on the scale of the developments in Iceland or Hungary yet exists. The federal government has been active in financing pilot direct-use projects through its Program Opportunity Notice (PON) and other related programs. The state government has been involved on a lesser scale, both in cooperation with the federal government and with its own direct-use projects. However, the level of support for direct-use applications through research and development programs, analysis of economic and institutional barriers to development, and long-range planning for utilization of direct applications has not been as significant as that devoted to electric power development.

The relatively high rate of geothermal development in California may be attributed to several factors. First, the federal and state governments have supported private industry through research and development efforts in the technical fields, cost-sharing of demonstration projects, and guaranteed financing of private projects. This has provided an investment climate conducive to the growth of the geothermal industry. Second, technological innovations and increasing proficiency in technological applications have placed California developers in the forefront of their fields internationally.* And third, the political climate in California has favored development of geothermal energy over conventional sources. This is both an economic as well as an environmental preference stemming from the oil crisis and the perceived risks of future fossil and nuclear power plants.

Present geothermal development activities in California are summarized in the following sections. Section 2.21 describes the present status of each power plant on-line or planned, the assumed potential capacity, and projected date on-line. A tabulation of existing and planned direct use projects is included in Section 2.2-2.

REFERENCES

1. Christopher H. Armstead, Geothermal Energy: Its Past, Present, and Future Contributions to the Energy Needs of Man, Halstead Press, 1978.

2. James Kuwada, October 26, 1979.

* For example, in the areas of exploration, resource evaluation, and reservoir engineering, U.S. developers are generally considered to have some advantage over their counterparts elsewhere in the world. In other areas (e.g., steam turbine development, direct use applications, etc.) the U.S. is deemed to be behind.

2.21 ELECTRIC POWER PRODUCTION

The first generation of field development proceeds from first-on-site applications, which test technical and economic feasibility for power production, to expansion of production to the entire reservoir. The second generation of development begins with additional exploration to define new reservoirs in the resource area. Very often, the initiation of second generation activities overlaps with the completion of development for the original field. Resource areas in California now are at all stages of development.

The Geysers region is already the largest producer of geothermal electric power in the world, with a total of 663 MWe on-line. Plant completions in 1980 will add an additional 250 MWe to this total. All the plants now in operation, and all those planned through 1988, utilize the vapor-dominated field. Planned expansion beyond 1988 will utilize the liquid-dominated reservoir presently being explored in The Geysers region.*

The other area of intensive geothermal development in California is the Imperial Valley. Here, development is still at a preliminary stage. Magma Power/San Diego Gas & Electric have just completed a 10 MWe test plant at Brawley, and are considering expansion of this facility to 48 MWe.

The geothermal resources being developed in the Imperial Valley are liquid-dominated. The ultimate capacity for electricity generation in the Imperial Valley region is estimated to be approximately three times that of The Geysers area.** A problem with the development of these resources has been the high concentration of dissolved solids (i.e., minerals and salts) in some of the geothermal reservoirs. A solution to the technlogical problems involved in handling geothermal fluids with up to 30% dissolved solids is necessary to development in this region.

On the following pages, a schedule of the power plant development activities is given for The Geysers (Table 2.21-1), the Imperial Valley (Table 2.21-2), and for the other remaining major areas (Table 2.21-3).

The footnotes accompanying each table discuss the special characteristics of the plant, including problems which may hamper scheduled development efforts. These issues are

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*See Table 2.21-1 for The Geysers utilization schedule.

**U.S. Geological Survey, Assessment of Geothermal Resources in the United States - 1978, USGS Circular 790, Arlington, Va., Tables 4 & 5.

further characterized according to technical, economic, environmental, and institutional issues in Section 4.22.

Table 2.21-1. Status of Electric Power Development Activities at The Geysers

GEO-THERMAL RESOURCE AREA	PROJECT			NET CAPACITY/ GENERATION TYPE	RESOURCE DEFINITION ACTIVITIES		POWER PLANT CONSTRUCTION		POWER ON LINE
	UTILITY/ UNIT	LOCATION/ COUNTY	DEVELOPER		EXPLORATION: -Planning/leasing -EIR/permits -drilling/testing	DEVELOPMENT: -permits -drilling/testing of production wells	DESIGN AND DEVELOPMENT: -planning/design -detailed design/ permitting (NOI/AFC)	CONSTRUCTION -site/facilities/equipment installation -transmission tie-in	
Geysers Steam	PG&E								
	1-12	Sonoma	Union	608	——	——	——	——	3/79
	13	Lake	Aminoil	135	——	——	——	—— 1	4/80
	14	Sonoma	Union	110	——	——	——	—— 2	8/80
	15	Sonoma	Thermogenics	55	——	——	——	—— 3	7/79
	16	Lake	Aminoil	110	——	——	—— 4		1/83
	17	Sonoma	Union	110	——	——	——	5	8/82
	18		Union	110	——	——	—— 6		1982
	19	Lake	Aminoil	110	——	—— 7			1986?
	20		Union	110	——	—— 8			1985
	21	Lake	Union	110	—— 9				1986
	22	N.I.	N.I.	110	—— 10				1988+
	23	N.I.	N.I.	110	—— 10				1988+
	24	N.I.	N.I.	110	—— 10				1988+
	25-27								
	NCPA								
	1	Lake	RFL	33/33	——	——	—— 11		1985
	2	Sonoma	Shell	55/55	——	——	——	12	1982
	DWR								
	Bottlerock	Lake	McCulloch	55	——	——	—— 13		1983
	Newfield	Lake	McCulloch	55+	——	——	—— 14		~~1983~~
	Rorabaugh	Sonoma	Geothermal Kinetics	55	——	——	—— 15		1984
	SMUD								
	1		Aminoil	50	——	——	—— 16		1984
	2		N.I.	55+	——	17			1985
	3		N.I.	55	——	17			1986
Geysers Hot Water			Phillips/ Borax						
			Union		18				
			Magma/ Watson		18				
Lower Lake/ Sulphur Bank					19				

References: *California Energy Commission, Geothermal Energy Updates, July 12, 1979, November 26, 1979, March 5, 1980.
**Systems Development Corporation, Regional Systems Development for Geothermal Energy Resources, Pacific Region (California and Hawaii). Task 1 - Implementation Plan Development, Topical Report. March 27, 1979.
***Communication with Judy Warburg, March 31, 1980.

Table 2.21-1 Footnotes.

1 PG&E/13: Construction continuing.* Unit 13 will have the largest generating capacity of any geothermal electric plant in the world - 135 MWe. It is the second dry steam plant anywhere designed to use a surface condenser (Unit 15 is the first so designed); and it will utilize the Stretford process for controlling H_2S emissions. This is the first geothermal power plant to be located in Lake County and will supply power to the Fulton Substation along a new 230 kV transmission line.**

2 PG&E/14: Construction continuing.*

3 PG&E/15: Unplanned 2-week outage caused by electrical malfunction 11/19/79. PG&E has succeeded in abating H_2S in the steam condensate without forming sludge and is designing a system to implement the process. Meanwhile, H_2S emissions may exceed the Northern Sonoma County APCD limits.*

4 PG&E/16: AFC resubmittal accepted 2/21/80 with additional analysis of air quality and abatement procedures.*

5 PG&E/17: AFC approved 9/20/79. Construction starts 4/1/80, weather permitting.*

6 PG&E/18: AFC decision expected 4/16/80.*

7 PG&E/19: PG&E not satisfied with proof of resource. Some "dry holes". No new wells to be drilled until summer 1980.* Schedules for projects subsequent to Unit 19 may change depending on completion of data on steam supply. These units are in the long range planning stage.**

8 PG&E/20: Cobb Mountain resource not proven; relocated between units 18 and 14. AFC expected 3/80.

9 PG&E/21: Cobb Mountain resource not proven; may relocate.*

10 PG&E/ 22-24: Contingent on steam supply.*

11 NCPA 1: NOI accepted; decision expected about 3/80. "Cobb Valley 1" well was completed.*

12 NCPA 2: AFC decision 3/12/80. NCPA Unit 2 will be built jointly by NCPA and the Plumas-Sierra Rural Electric District to serve Lodi, Roseville, Santa Clara, Alameda, Ukiah, Healdsburg and Lompoc. The project is procedurally complicated because it will involve the preparation of a Joint Environmental Statement by three federal agencies (BLM, USGS, and DOE) with CEC acting as the lead agency and Sonoma County participating as the responsible agency under the California Environmental Quality Act. Also, since, the plant will be located on federal land, the Federal Plans of Operation will be needed. These plans, the JES, and the usual State NOI/AFC process will all be prepared concurrently.**

13 DWR/Bottle Rock: AFC extension granted. Status of project conference scheduled for 3/6/80.* The power plant is to be entirely funded by DWR. The land is privately owned by the Francisco family and is currently leased by McCulloch/GKI/Entrex as the field developers for the project. Bechtel has been selected to prepare the engineering design for the power plant.**

14 DWR/Newfield: NOI plans delayed - DWR has abandoned project dued to inability of developer to get necessary permits from Lake County.*** The Lake County Board of Supervisors have upheld the Planning Commission's decision to deny McCulloch's application to drill an exploratory well near an existing subdivision. McCulloch is suing Lake County over the decision.

15 DWR/South Geysers: NOI submitted 10/22/79; accepted 11/19/79.*Rorabaugh or "South Geysers" is in the planning stage. H_2S is not considered to be a problem as GKI/DWR will use whatever equipment is found to be satisfactory by PG&E.**

16 SMUD/1: 21 month AFC submitted 2/19/80.*

17 SMUD/2: SMUD is in the process of negotiating steam supply.*

18 As of March, 1979, none of the utilities contacted by Systems Development Corporation had any present plans to use hot water resources which might be discovered at the Geysers. The general concensus is that until the steam resources have been exploited to the maximum, no hot-water resources will be developed.**

19 It is well known that many hot springs exist around the Clear Lake area and that a 186°C hot water reservoir was discovered at Sulphur Bank. Further geological studies are required to confirm these hot-water prospects.**

Table 2.21-2. Status of Electric Power Development in the Imperial Valley

GEO-THERMAL RESOURCE AREA	PROJECT: UTILITY/ UNIT	PROJECT: COUNTY	PROJECT: DEVELOPER	NET CAPACITY/ GENERA-TION TYPE	RESOURCE DEFINITION ACTIVITIES: EXPLORATION: -Planning/leasing -EIR/permits -drilling/testing	RESOURCE DEFINITION ACTIVITIES: DEVELOPMENT: -permits -drilling/testing of production wells	POWER PLANT DEVELOPMENT: DESIGN AND DEVELOPMENT: -planning/design -detailed design/ permitting (NOI/AFC)	POWER PLANT DEVELOPMENT: CONSTRUCTION: -site/facilities/equip-ment installation -transmission tie-in	POWER ON LINE
Imperial Valley									
Heber	SCE		Chevron	50FF	====	====	==== 1		1982
	SCE		Chevron	100F	====				1986
	SDG&E		Chevron	50	====	==== 2			1984
	SDG&E		Chevron	100F	====				1986
East Mesa	SDG&E		Magma	10B	====	====	====	==== 3	1980
	SDG&E		RGI	10-48	====	====	==== 4		1982
	SDG&E		Magma (Expanded)	40	==== 5				1984
Salton Sea	SCE		Mono/Union /S. Pacific	10	====	====	==== 6		1982
	SCE		Mono/Union /S. Pacific (expanded)	40	==== 6				1985
	SCE		Union	50	====				1987
	SCE			100	====				1990
	SDG&E		Magma/NARCO	49F	====	====	==== 7		1982
E. Salton Sea	DWR		McCulloch	55F	==== 8				~~1984~~
Brawley	SCE		Union	10F	====	====	====	==== 9	1980
	SCE		Union	50F	==== 9				1984
	SCE		Union	100F	==== 9				1985
S. Brawley	DWR		CUI Venture	55F	====	==== 10			1984
Westmorland	SDG&E		RGI/MAPCO	48F	==== 11				1983

References: *California Energy Commission, Geothermal Energy Updates, July 12, 1979, November 26, 1979, March 5, 1980.
**Systems Development Corporation, Regional Systems Development for Geothermal Energy Resources, Pacific Region (California and Hawaii). Task 1 - Implementation Plan Development, Topical Report. March 27, 1979.
***Communication with Judy Warburg, March 31, 1980.

Table 2.21-2. Footnotes.

1 SCE/Chevron (50FF): Preliminary engineeringa tudies have been completed; production permit granted by Imperial County Board of Supervisors 1/80.* Agreement with Chevron for sale of steam was signed prior to 12/15/78. SCE considers the flashed steam plant to be a lower risk than the binary (as it makes use of technology already successfully demonstrated at Cerro Prieto). The main objective of the pilot plant is to demonstrate the technical and economic feasibility of electric power production at this reservoir.**

2 SDG&E/Chevron (50): PUC passed resolution allowing SDG&E to spend $2M in 1980 R&D funds; production permit granted by Imperial County Board of Supervisors.* This is the SDG&E binary plant that was originally planned as a SDG&E/DOE demonstration project. SDG&E is now seeking additional funds from several utilities and developers. If the plant is delayed much beyond 1983, certain permits and contracts may have to be renewed or renegotiated. Committments for make-up water will be of particular concern.**

3 SDG&E/Magma (10B): Startup delayed by problems with hydrocarbon seals.* This pilot plant will utilize the Magmamax dual binary cycle conversion system. Geothermal fluids will flash isobutane which drives the primary turbine. Residual heat in the isopropane turbine exhaust will flash propene which drives another turbine.**

4 SDG&E/RGI (10-48): Construction of 10 MWe pilot plant is expected to begin 3/80.* A letter of understanding was signed 7/24/78 for RGI to arrange financing and construct the power plant, SDG&E to operate it. The initial 10 MWe pilot plant is funded by RGI with a DOE loan guarantee of $9M covering about half of the total of 30 wells required for the plant. Imperial County has granted permission for 87% reinjection at this site on an experimental basie to assess potential subsidence. This project, often referred to as a "48 MWe" power plant, is in fact composed of a 10 MWe and a 54 MWe generating unit whose net output is 48 MWe. Another loan guarantee has been submitted for power plant contruction.**

5 Magma (40B): Magma will probably seek both a geothermal loan guarantee and utility commitment before proceeding with the expansion of the pilot plant.**

6 SCE/Mono etal (10): Principals applied for conditional use permit (1/80).* Per exploration agreement signed 4/24/78 between Union Oil, Mono Power (SCE subsidiary) and Southern Pacific Land Co., Union will drill and test 4 new wells near Niland beginning September, 1978 to determine the best techniques to extract, handle and reinject geothermal fluids.**

7 SDG&E/Magma-NARCO (50F): Production permit granted by Imperial County Board of Supervisors (1/80); Morrison Knudson is doing engineering and design studies.* Magma will probably finance this effort with a guarantee and will undertake the acutual construction. SDG&E will operate the plant after leasing or purchasing it.

8 DWR/McCulloch (55F): This was the Frinks Springs Project. An exploratory well drilled by McCulloch was unsuccessful and the project is no longer considered by DWR.***

9 SCE/Union (10F): Plant construction is approximately 40% complete.* Successful operation of the initial 10 MWe plant will lead to a 50 MWe plant in 1984, followed by a 100 MWe plant in 1985.

10 DWR/CUI Venture (55F): McCulloch Geothermal Resources signed an agreement with DWR on November 3, 1978 to develop the Brawley reservoir under a DOE loan guarantee. CUI (California-Utah) Venture, which is a joint venture between McCulloch and Geothermal Kenetics Inc. is carrying out field development activities under a loan guarantee of $1.8M (75% of $2.5M).**

11 SDG&E/RGI-MAPCO (48F): Westmorland Geothermal Associates are drilling exploratory wells under a geothermal loan guarantee (2/80).*

Table 2.21-3. Status of Electric Power Development Activities at Coso, Mono-Long Valley, Wendell-Amedee, Surprise Valley, Lassen, and Glass Mountain

GEO-THERMAL RESOURCE AREA	PROJECT			NET CAPACITY/ GENERATION TYPE	RESOURCES DEFINITION ACTIVITIES		POWER PLANT DEVELOPMENT		POWER ON LINE
	UTILITY/ UNIT	LOCATION/ COUNTY	DEVELOPER		EXPLORATION: -Planning/leasing -EIR/permits -drilling/testing	DEVELOPMENT: -permits -drilling/testing of production wells	DESIGN AND DEVELOPMENT: -planning/design -detailed design/ permitting (NOI/AFC)	CONSTRUCTION: -site/facilities/equipment installation -transmission tie-in	
Coso	DOE/NWC	China Lake	CER	12	1				
	Pilot Plant		CER	50					
Mono-Long Valley	SCE	Mammoth Lakes	Magma	32 (Co-gen.)	2				
Wendel-Amedee	DWR		Magma	55 (Co-gen.)	3				
Surprise Valley			Magma Energy Gulf Oil		4				
Lassen Valley			Phillips Petroleum		5				
Glass Mountain					6				

References: *California Energy Commission, Geothermal Energy Updates, July 12, 1979, November 26, 1979, March 5, 1980.
**Systems Development Corporation, Regional Systems Development for Geothermal Energy Resources, Pacific Region (California and Hawaii). Task 1 - Implementation Plan Development, Topical Report. March 27, 1979.
***Communication with Judy Warburg, March 31, 1980.

1 DOE-NWC/CER (12): A draft environment impact statement is in preparation. DOE funded the drilling of a test well in 1977, but results were disappointing and further tests are being carried out.

2 SCE/Magma (32 Co-gen.): SCE and others are evaluating results of a direct use feasibility study at Mammoth Lakes Village, including the possibility of a co-generation electric power plant. However, residents in the area have voiced opposition to a power plant due to possible vapor plumes that would emanate from cooling towers.**

3 DWR/Magma (55 Co-gen.): DWR and Geoproducts, Inc. are preparing a cogeneration power plant design for Wendel-Amedee. Wood waste will be procurred from lumber mills in the region and geothermal steam will be used to dry the waste to increase its heating value. The steam will then be passed through a heat exchanger the boiler feedwater to the wood-waste fired boiler. Both the reservoir and the 55 MWe power plant will be operated by Geoproducts; DWR will purchase the power. The waste steam from the power plant will be used to warm several hundred greenhouses. The plant is schedule to be operational in 1983 or 1984. It is contingent upon proof of an adequate resource and financing being available.**

4 Surprise Valley KGRA: No power on-line through 1990 is envisioned for this area. All four towns in the Valley are near resources of varying temperature which are generally more suitable for direct heat applications.**

5 Lassen Valley: At present, no geothermal power plants are being planned at Lassen through 1990 and beyond. Population and industrial density in this area are very low.**

6 Glass Mountain: No power plants are planned in this KGRA located in Siskiyou County at the present time. No geothermal wells have been drilled on private lands or on federal lands in the Klamath National Forest. The decision to lease additional Forest Service lands is scheduled for late 1980 and is predicated upon the completion of a US Forest Service recreational plan.**

2.22 DIRECT HEAT UTILIZATION

Low and moderate temperature geothermal resources are located in many areas of California and could potentially be used for agriculture, tourism, industrial processing, space heating, cooling, and refrigeration. The USGS has identified 24 hot-water convection systems in California with subsurface temperatures ranging from 90°C to 150°C; and 14 systems of less than 90°C geothermal water (see Tables 1.2-3, 1.2-4). The locations of these low and moderate temperature areas are shown in Figure 2.1-1.

With the exception of commercial spas, which were developed in California in the early part of the century, only a few direct-heat applications are in operation. Existing projects include greenhouses, catfish and prawn farming, and space and water heating. Both the Department of Energy and the California Energy Commission are encouraging the direct use of low-to-moderate temperature resources through sponsorship of demonstration projects, and engineering and economic studies at specific sites.

A tabulation of commercial spas is presented in Table 2.22-1, and their locations are indicated on Figure 2.22-1. Fifteen existing and potential direct-use projects sponsored by the Department of Energy and/or the State of California are summarized in Table 2.22-2. Potential projects refer to those that have been a part of a DOE engineering and economic study (PRDA) or have been approved as field demonstration (PON).

Table 2.22-1. Commercial Spas in California

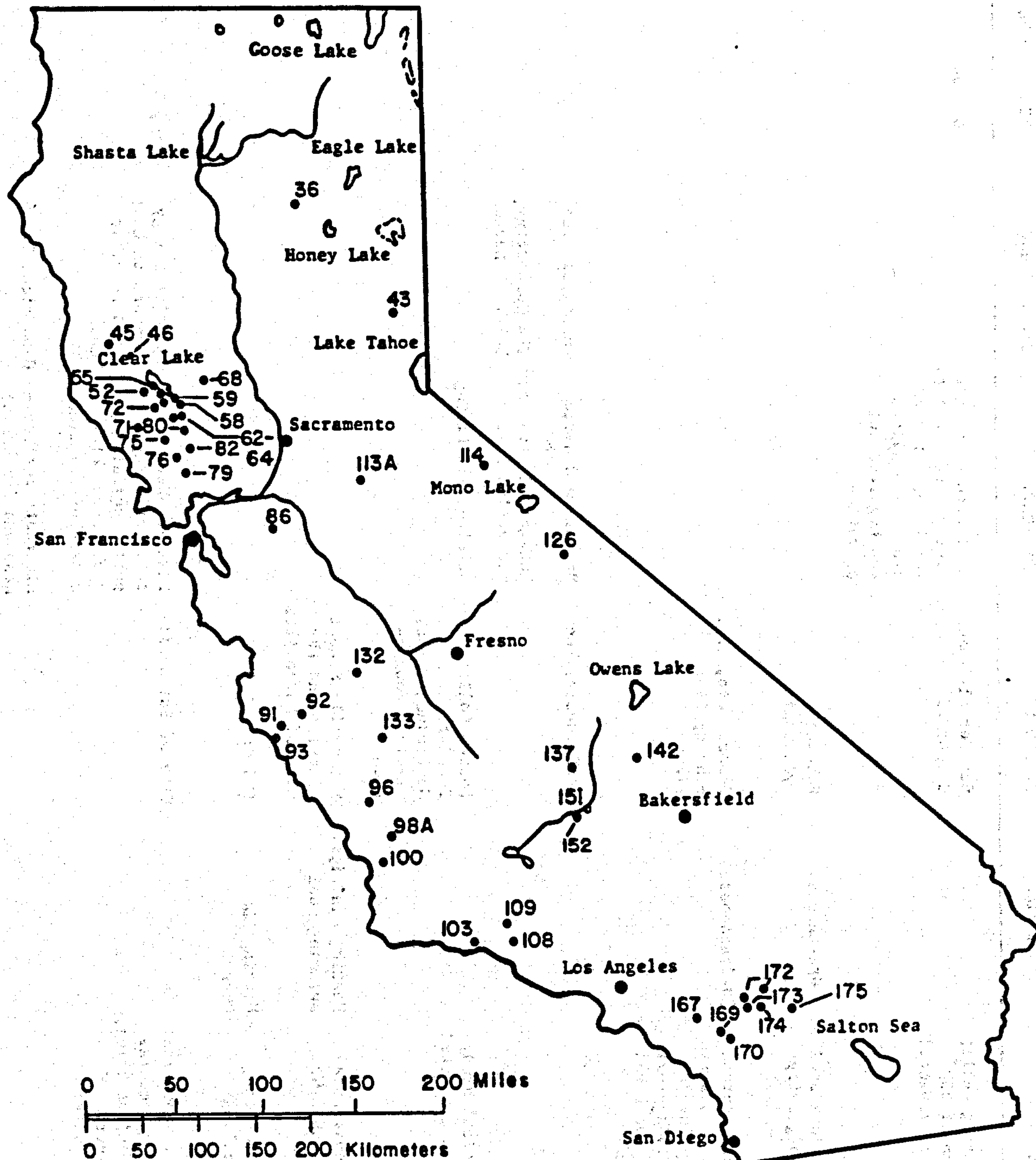
Number on Fig. 2.22-1	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	Remarks
36	Drake Hot Springs, 6 miles southeast of Lassen Peak and 70 miles northeast of Red Bluff.	123-148	20	----do----------	4 springs. Resort.
43	Campbell (Upper Soda, Freys) Hot Springs, 2 miles south of Sierraville.	65-111	80	Faulted andesite	11 springs. Resort. 297.
44	Brockway (Carnelian)Hot Springs, on north shore of Lake Tahoe and 13 miles southeast of Truckee.	120-140	150	Andesite overlying faulted granodiorite.	6 springs. Resort.
45	Orrs Hot Springs, 16 miles northwest of Ukiah.	63-104	25	Franciscan Formation (Jurassic and Cretaceous).	7 springs. Resort.
46	Vichy Springs, 3 miles northeast of Ukiah.	50-90	30	Sandstone (Franciscan Formation) near lava.	7 springs. Resort.
52	Highland Springs, 6 miles southwest of Kelseyville.	52-82	20	Serpentine (Franciscan Formation)	11 springs. Resort.
55	Soda Bay Springs, at base of Mount Konocti.	80-87	400	Lava (Quaternary)	5 springs. Resort.
58	Howard Springs, 28 miles north-northwest of Calistoga.	48-110	135	Sandstone and serpentine (Franciscan Formation).	26 springs. Resort.
59	Seigler Springs, 30 miles north-northwest of Calistoga.	58-126	35	Serpentine (Franciscan Formation).	13 springs. Resort.
62	Castle (Mills) Hot Springs, 25 miles north-northwest of Calistoga.	65-164	--------	Schist (Franciscan Formation).	2 springs. Resort.
63	Anderson Springs, 22 miles north-northwest of Calistoga.	63-145	7	Lava and schist (Franciscan Formation).	9 springs. Resort. 284, 286.
64	Harbin Springs, 20 miles north-northwest of Calistoga.	90-120	10	Schist (Franciscan Formation).	3 springs. Resort. 253, 284.
68	Wilbur (Simmons) Hot Springs, 26 miles southwest of Williams.	65-140	35	Serpentine and sandstone (Franciscan Formation).	12 springs. Resort. 284.
71	Skagg's Hot Springs, 9 miles west-southwest of Geyserville.	120-135	15	Fractured sedimentary strata (Franciscan Formation).	3 springs. Resort. 297.
72	The Geysers, 18 miles east-southeast of Cloverdale.	140 to	30-50	Fractured sedimentary strata (Franciscan Formation).	About 30 springs, including Iron, Witches' Cauldron, Devil's Teakettle, and Acid. Water is bottled for drinking. Resort. Also wells produce steam for electricity.
75	Mark West Warm Springs, 7 miles northeast of Fulton.	60-82	30	Lava and tuff (Pliocene).	9 springs. Resort.
76	Los Guilicos Warm Springs, 3.5 miles southwest of Glen Ellen.	78-82	5	Franciscan Formation.	2 springs. Resort.
79	Fetters Hot Springs, 2.75 miles northwest of Sonoma.	100	--------	----------------	4 pumped wells. Resort
80	Aetna Springs, 17 miles north of St. Helena.	63-92	20	Franciscan Formation.	6 springs. Water used
82	St. Helena White Sulphur Springs, 2 miles southwest of St. Helena.	69-90	6	Sandstone (Franciscan Formation)	5 springs. Resort.
86	Byron Hot Springs, 2 miles south of Byron.	72-120	15	Sedimentary strata (upper Miocene).	7 springs. Resort. 253.
91	Tassajara Hot Springs, in sec. 32, T. 19 S., R. 4 E.	100-140	100	Gneiss and granite	17 springs. Resort.
92	Paraiso Hot Springs, 8 miles south-southwest of Soledad.	65-111	10	Sandstone (Miocene)	5 springs. Resort.

Table 2.22-1 continued

Number on Fig. 2.22-1	Name or location	Temperature of water (°F)	Flow (gallons per minute)	Associated rocks	Remarks
93	Slate's Hot Springs, in sec. 9, T. 21 S., R. 3 E.	100-121	50	Sedimentary strata (Upper Cretaceous).	10 springs. Resort.
96	Paso de Robles Hot Springs, in southwest part of Paso Robles.	105	1,700	----do----------	1 main spring and flowing well. Resort
98A	San Luis (Sycamore) Hot Springs, 8 miles south-southwest of San Luis Obispo.	107	50	----------------	Well. Resort.
100	Newsom's Arroyo Grande Warm Springs, 2.5 miles east of Arroyo Grande.	98	15	Fractured siliceous shale (Miocene).	Resort.
103	Montecito (Santa Barbara) Hot Springs, 6 miles northeast of Santa Barbara.	111-118	50	Sandstone (upper Eocene)	11 springs. Resort. Part of Montecito water supply.
108	Matilija Hot Springs, 6 miles northwest of Nordhoff.	65-116	45	Sandstone and shale (upper Eocene).	4 springs. Resort.
109	Wheeler's Hot Springs, 7.5 miles north-northwest of Nordhoff.	62-102	40	----do----------	4 springs. Resort.
114	Fales' Hot Springs, in sec. 24, T. 6 N., R. 23 E., 13 miles northwest of Bridgeport.	97-141	300	Lava near granite	Several springs. Deposit of tufa. Resort.
126	Whitmore Warm Springs, in sec. 18, T. 4 S., R. 29 E.	90	306	Faulted lava (Quaternary).	2 main springs. Resort
133	Fresno Hot Springs, on branch of Waltham Creek, 18 miles west of Coalinga.	88-97	20	Faulted sandstone and shale (Miocene?).	5 springs. Resort.
137	California (Deer Creek) Hot Springs.	105-126	50	Faulted granite	7 springs. Resort.
142	Coso Hot Springs, 20 miles northeast of Little Lake.	140 to boiling	Small	Lava (Recent) overlying granite.	3 main springs. Steam baths. Resort.
151	Delonegha Springs, 45 miles northeast of Bakersfield.	104-112	25	Fractured granite	3 springs. Resort.
152	Democrat Springs, 40 miles northeast of Bakersfield.	100-115	25	Faulted granite	5 springs. Resort.
167	Glen Ivy (Temescal) Hot Spring, 11 miles south-southeast of Corona.	102	15	Faulted granite	1 main and several minor springs. Resort
169	Elsinore Hot Springs, 50 yd. north of Elsinore depot.	125	--------	Quaternary deposits rear faulted Mesozoic rocks.	3 springs which but are now pumped.
170	Murrieta Hot Springs, 4 miles east-northeast of Murietta.	134-136	75	Faulted granite	3 springs. Resort.
172	Eden Hot Springs, 9 miles southwest of Beaumont.	90-110	30	Faulted granite	8 springs. Resort.
173	Gilman (San Jacinto, Relief) Hot Springs, 6 miles northwest of San Jacinto.	83-116	20	Alluvium overlying gneiss	6 springs. Resort.
174	Soboba (Ritchey) Hot Springs, 2.5 miles northeast of San Jacinto.	70-111	25	Faulted gneiss	6 springs. Water bottled and used for irrigation. Resort.
175	Palm Springs, 6 miles south of Palm Springs station.	100	5	Faulted granite	2 springs. Resort.

Source: Adapted from Bill Kaysing, Great Hot Springs of the West, Capra Press, Box 2068, Santa Barbara, California 93120, 1974.

Figure 2.22-1. Commercial Spas in California



Source: Adapted from Bill Kaysing, Great Hot Springs of the West, Capra Press, Box 2068, Santa Barbara, California 93120, 1974.

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TABLE 2.22-2. EXISTING AND POTENTIAL DIRECT USE PROJECTS IN CALIFORNIA.

LOCATION	RESOURCE STATUS	EXISTING APPLICATION	DEVELOPER	POTENTIAL APPLICATION	FEASIBILITY STUDY (PRDA)	COST-SHARED FIELD EXPERIMENT TEC	DOE SHARE	COMMERCIAL
1. Kelley Hot Springs	2 existing wells; 325 gpm of 230° water is expected		Geothermal Power Corporation	Agricultural center -integrated facility for livestock feed production system and hog feed lot pperation		6,000k	30%	
2. Wendel -Amedee	Hot springs used through gravity flow	6 Greenhouses	Hobowells Hydroponics					Use of SBA Loans
3. Wendel -Amedee	GPI has obtained rights to 3 exist -ing springs; yield is approximately 206°F and 317 gpm	30 Greenhouses	Geoproducts, Inc. - Honey Lake Farms					Private investors
4. Wendel -Amedee			GeoProducts, Inc.	Drying wood waste	In negotiation			
5. Wendel -Amedee				Integrated livestock production system	CLR Consortium, Univ. of Nevada			
6. Wendel -Amedee	Geophysical study has been conducted by GPI		Lassen College Foundation; GeoProducts, Inc. Skakless Foundation	Alfalfa pelletizing				
7. Susanville	Pool constructed in 1934 unde WPA	Heating municipal swimming pool	Susanville School District and the City of Susanville					
8. Susanville	Minor problems with scaling	Heating LDS Church	LDS Church					Funded by church members
9. Susanville	US WPRS assessment including temperature gradient holes; resistivity and seismic surveys		City of Susanville	District Heating to 17 existing public buildings; development of a park of commerce	Aerojet Energy Conversion Co.; Fred Longyear Co.	$4,300k	45%	
10. Lake County				Alternate agribusiness and industrial uses for exhaust heat from geothermal waste fluid	Geonomics, Inc.			

TABLE 2.22-2.

LOCATION	RESOURCE STATUS	EXISTING APPLICATION	DEVELOPER	POTENTIAL APPLICATION	FEASIBILITY STUDY (PRDA)	COST-SHARED FIELD EXPERIMENT TEC	DOE SHARE	COMMERCIAL
11. Lake County	3 sites are under consideration			Total Energy Recovery System for Agribusiness	International Engineering Co.			
12. Casa Diablo Hot Springs -Mammoth Lakes	8 shallow wells; well head temp 330°F to 340°F; flow rates 300,000 - 500,000 lbs/hr.	Demonstration project: geothermal heating system and snow smelting	California Energy Commission	District space and water heating system	The Ben Holt Co; Southern California Edison; Ayers Associates; Magma Energy, Inc.			
13. Paso Robles	1 well - 117°F yielding 1,400 gpm potable water with overabundance of H_2S.	Fish farming; effluent is used to irrigate a 170 acre alfalfa crop	Calaqua Inc.					TEC: $3,000 Calaqua Inc., & British Oxygen Co.
14. Mecca, Coachella Valley	3 existing shallow wells with temp. 84°F - 87°F		Aquafarms International, Inc.	Expansion of existing geothermally supplied system to raise giant Malaysian prawns		$1,090K	33%	
15. Desert Hot Springs	Relatively new and undefined reservoir	Spas and hotel pools	City of Desert Hot Springs	Greenhouses and raceway culturing of freshwater prawns	Joint California Energy Commission and DOE Project: Jet Propulsion Laboratory			
16. Bishop			Union Carbide Company	Tungsten metal processing	Westec Services, Inc.			
17. East Mesa			Holly Sugar Refinery	Design, installation and operation of a geothermal system to be use for process heat	TWR, Inc.	$18,000k	22%	
18. East Mesa				Corn milling plant	Burns & Roe Industrial Service Corp			
19. El Centro	Site overlies Heber KGRA; 3 existing wells		Valley Nitrogen Products	Production of fertilizer using a geothermal system for process heat	Westec Services, Inc.			
20. El Centro	Site located on border of Heber KGRA		City of El Centro	Geothermal space cooling, heating and water heating for the city's community center. It is intended to serve as the core of a future district heating and cooling system	Aerojet Energy Conversion Co.	$2,650k	70%	

Source: Department of Energy, San Francisco Operations Office, 1980.

RESOURCE PROFILE
DEVELOPMENT ACTIVITIES

3. ENERGY SUPPLY and DEMAND

GEOTHERMAL ENERGY MARKET
GOVERNMENT ACTIVITIES and INITIATIVES
PRIVATE SECTOR ACTIVITIES
SIGNIFICANT EVENTS

SECTION 3: CALIFORNIA ENERGY DEMAND AND SUPPLY PROFILE

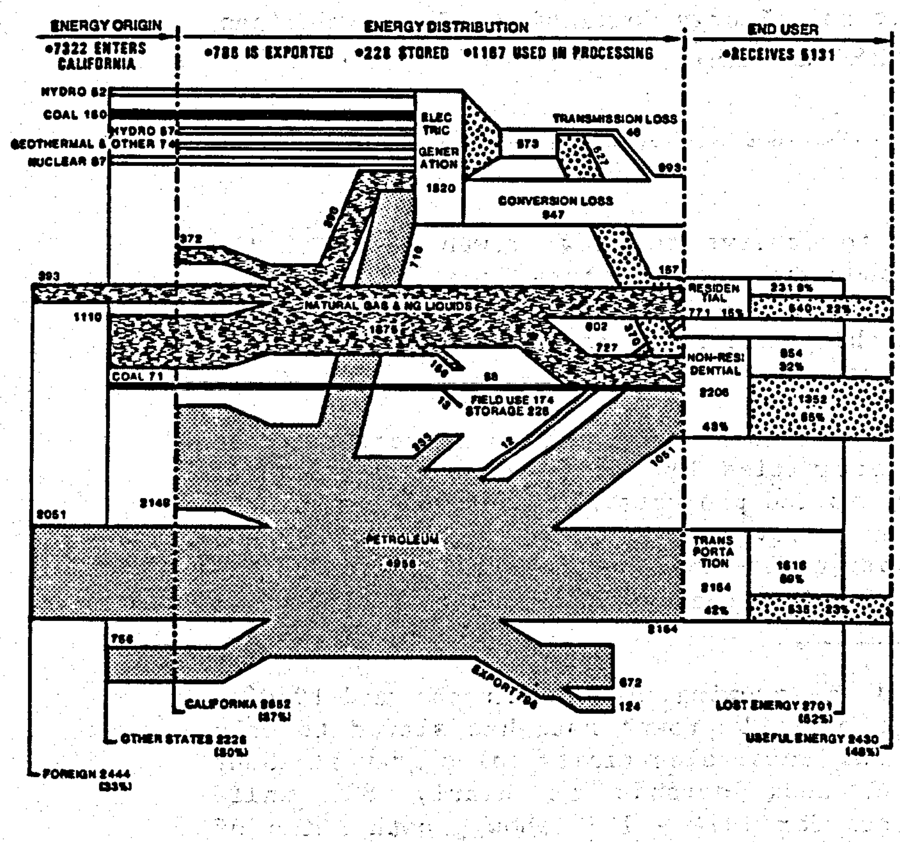
The purpose of Section 3 is to provide a general overview of present and projected energy demand and supply patterns in California and to identify the energy sectors which may be affected by future geothermal development. Selected end-use demands by sector (residential, commercial, and industrial) are described, and their relationship to the development of geothermal resources for electricity generation and direct use applications are discussed. Various projections of demand and supply patterns are summarized to show the diversity of alternative energy scenarios in the state. Forecasts of energy demand vary widely in the scenarios developed by the California Energy Commission, the absolute contribution to the energy supply mix from geothermal resources during the period 1985-1990 is in the range of 1,700 MWe to 3,600 MWe for all scenarios. The significance of the geothermal energy share increases from 1% (1980) to 5% by 1998, with the exception of one energy scenario (high emphasis on renewable energy resources) where the projected share will increase to 15%.

3.1 ENERGY SUPPLY AND DEMAND OVERVIEW

Energy is supplied in California from a variety of sources to many end-users. Data for 1977 indicate that 92% of California's energy comes from either natural gas (28%) or petroleum products (64%). The remaining 8% is supplied by hydropower and nuclear (5%) and coal (3%). Geothermal supplies less than 1% of the total demand.[1]

California, like the United States as a whole, depends on imports to meet a substantial portion of the energy demand. The state now imports nearly 60% of its oil, 80% of its natural gas, and approximately 17% of its electricity. Figure 3.1-1 summarizes the energy demand and supply mix for 1977.

Figure 3.1-1. 1977 California Energy Flow (Total Consumption 6298 Trillion Btu)



Source: California Energy Commission, Energy Choices for California, Looking Ahead, Sacramento, California, March 1979.

Overall demand for energy in the state is now growing at a slower rate than the historical trend established than at any time since 1950.* Table 3.1-1 presents data for energy consumption by economic sector.

Table 3.1-1. California Energy Consumption by Sector (Trillion Btu)

Economic Sector	1975	1977	%/Yr. 1975-1977
Residential	827	771	-3.4
Non-residential	2,395	2,380	-
Transportation	1,893	2,154	6.7
Electricity Conversion Loss	675	993	2.4
Total	5,790	6,298	4.4

Source: California Energy Commission, Energy Choices for California, Looking Ahead, Sacramento, California, p. 17, March 1979.

It is interesting to observe the low growth rates in the residential and non-residential sectors from 1975 to 1977. Residential energy consumption actually declined at a rate of 3.2% per year while non-residential energy consumption remained virtually static.**

Low growth rates in energy consumption reflect increasing conservation activities by energy consumers. Several state-adopted programs and projects have served to slow the energy consumption rates. Strict building standards have been enacted for both residential and non-residential buildings.[2] The California Energy Commission (CEC) has

*Energy demand was growing at 5.1% in the mid-1960's, but after 1974 the overall growth rate has slowed to only 1.1% per year. In the 1960s, electricity sales grew at about 9% per year, and peak demands at nearly 8%, while corresponding figures for 1974 - 1978 show growth rates of 3.2% and 4.5% per year, respectively.

**It is perhaps equally interesting to observe the enormous increase in electricity conversion losses, as high-efficiency hydroelectric capacity is supplanted by fossil fuel and nuclear plants.

established energy efficiency levels for refrigerators, freezers, room air conditioners, water and space heaters, and plumbing fixtures sold in the state.[3] In addition, the Public Utilities Commission and the CEC have established several programs with utilities and major industrial fuel users designed to conserve energy. These include conservation advertising with utility bills, promoting cogeneration options with industry, and establishing voltage limitations on utility electrical distribution lines.

However, in the short term (1980-1990) it is reasonable to assume that new supply sources will be required even if there is vigorous conservation. This is because existing electrical generation facilities will be retired and because fossil and nuclear sources are becoming more expensive.

Geothermal energy can reduce dependence on fossil and nuclear energy in California by meeting requirements for baseload electric power and process heat for certain end uses.

Development of geothermal energy can only occur when a suitable resource can be matched to a specific application. Relatively high temperature resources (greater than 150°C) are required for electricity generation. Moderate-low temperature resources (90°C to 150°C) are suitable for a range of direct applications (e.g., industrial process heat, agricultural applications, space conditioning, and hot water heating).

The following sections will focus on the energy supply and demand patterns for electric power production and the sectors of the economy where geothermal energy can make a significant contribution.

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2. California State Senate Bill 144 (1979) and Senate Bill 277 (1979).

3. California Energy Commission, Title 20, Article 4.

3.2 ELECTRIC POWER PRODUCTION

CURRENT SUPPLY AND DEMAND PATTERNS

California is heavily dependent upon three energy sources (petroleum, natural gas, and hydro) which are either relatively scarce or affected by climatic conditions. Table 3.21-1 summarizes the various fuels used for the production of electricity in both California and the United States.

Table 3.21-1. California and United States Electricity Production by Fuel Type

Source	California 1977 MW	%	United States 1978 MW	%
Petroleum/Natural Gas	22,700	60	219,087	39
Coal	2,500	7	213,592	38
Hydro	7,400	19	63,458	12
Nuclear	1,400	4	4,367	.9
Geothermal	500	1	500	.1
Cogeneration	200	-	--	-
Other	3,500	9	11,250	2
Total	38,200	100	562,300	100

Sources: California Energy Commission, Energy Choices for California, Looking Ahead, Sacramento, California, March 1979. Lawrence Berkeley Laboratory, An Energy-Environment Data Base for the States of California, Hawaii and Nevada, LBL-7821, Berkeley, California, 1979.

Relatively little (7%) of California's electricity is produced from coal and none of the 2,500 MW of coal generating capacity is located in California. Rather, several California utilities own parts of coal fired plants in surrounding states. By comparison, coal accounts for 38% of electricity production in the entire U.S. Two other notable differences are that California has nearly 11% of the nation's hydroelectric capacity and almost 100% of the installed geothermal capacity.

California Utilities

There are five major electric utilities in California: Pacific Gas & Electric Company (PG&E), Sacramento Municipal Utility District (SMUD), San Diego Gas & Electric (SDG&E), Southern California Edison (SCE), Los Angeles Department of Water and Power (LAWPD). (See Figure 3.21-1)

These five utilities supply nearly 95% of the electricity consumed in the state. In Table 3.21-2, the generating capacities of major utilities according to fuel type are summarized.

It is important to recognize the wide variation among the generation mix of California utilities. For instance, PG&E and SMUD are heavily dependent upon hydro, while SDG&E, SCE, and LADWP are dependent upon oil and natural gas. The difference reflects the geographic conditions of the respective service areas. PG&E and SMUD serve Northern California, where the climate and physical terrain are suitable to hydro, while there is no similar hydro capacity in Southern California.

Electrical energy demand in California is compared with demand in the U.S. in Table 3.21-3.

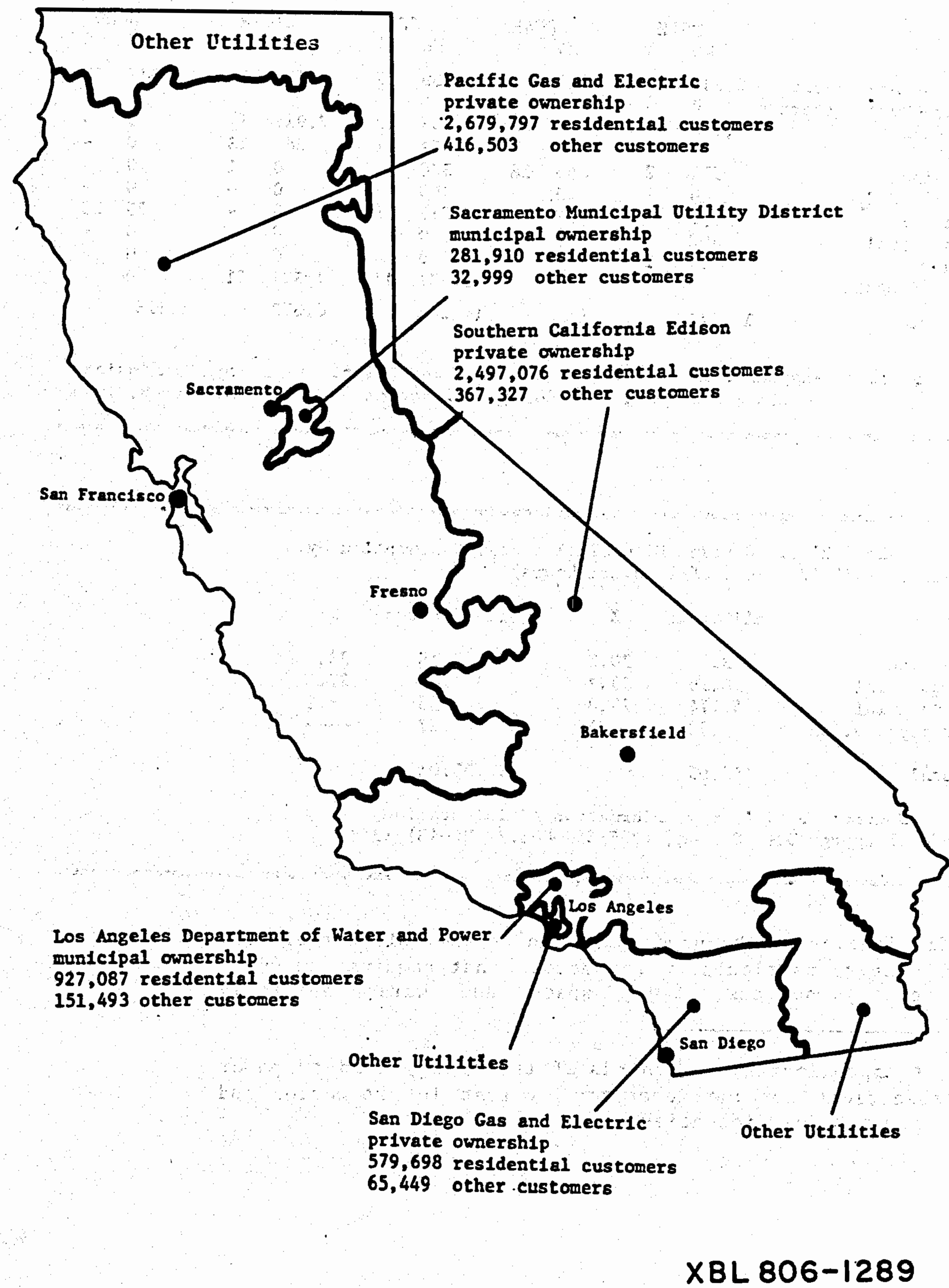
The wide variation in electrical energy use in the industrial sector can be partially explained by the fact that California does not have as much energy-intensive process industry (i.e., steel mills, aluminum mills, etc.) as the rest of the nation. Rather, California industry is characterized by manufacturing and assembly, e.g., electronics and aerospace industries.[1] It is difficult to explain the variation between California and national commercial energy use because of various accounting practices which define the commercial sector differently for California and the U.S.[2]

The historical pattern of declining growth for electricity between 1963-1978 is shown in Table 3.21-4.

It is important to note the difference in growth rate between sales (KWH) and peak (MW). Because peak demand is growing faster than sales, utilities will experience lower load factors which ultimately will raise the rates which consumers pay. These trends can be mitigated by conservation efforts and the ability of all consumers to shift demand to different periods of the day.

In addition to meeting electric power production requirements, geothermal may affect electricity demand in the residential, commercial, and industrial sectors if direct thermal applications can be substituted for certain end-uses that now use electricity. This substitution would result in some overall energy savings by avoiding

Figure 3.2-1. Electric Utilities Service Areas in California



Source: California Energy Commission, Energy Watch, Vol. 1, No. 4, July 1978. CEG Common Forecasting Methodology II, Docket No. 77-EA-10, March 1978.

Table 3.21-2. Generating Capacity of Major Electric Utilities in California in 1977.

Fuel Type	PG&E MW	PG&E %	SDG&E MW	SDG&E %	SCE MW	SCE %	LADWP MW	LADWP %	SMUD MW	SMUD %
Hydro-conventional	5,647	38	0	-	739	5	704	11	643	42
Hydro-pumped storage	0	-								
Oil/Gas	7,309	49	1,608	78	8,858	62	2,915	44	0	-
Coal	0	-	0	-	1,631	11	866	13	0	-
Turbines	251	2	368	18	550	4	80	1	0	-
Combined Cycle	0	-	0	-	490	3	0	-	0	-
Nuclear	933	6	87	4	349	3	0	-	875	58
Geothermal	502	3	0	-	0	-	0	-	0	-
Other	199	1	0	-	0	-	0	-	0	-
Out of State	0	-	0	-	1,631	11	1,377	21	0	-
Total	14,841		2,063		14,248		6,572		1,518	

Source: Adapted from utility filings with the California Energy Commission Common Forecasting Methodology II, docket No. 77-EA-10, March, 1978.

Table 3.21-3. Current Electrical Energy Consumption by Sector, 1975 (Billions of kilowatt-hours)

Sector	California	%	United States	%
Residential	43.38	30.3	568.15	33.8
Commercial	56.96	39.7	481.04	27.8
Industrial	42.74	29.8	661.56	38.2
Transportation	.28	.2	4.27	——
Total	143.65		1,733.01	

Source: U.S. Energy Information Administration, Federal Energy Data System, (DOE/EIA-0031/2 UC-13) 1978.

inefficiencies in the production and transmission of electrical energy, particularly in sectors that require low quality energy sources, e.g., space and water heating.*

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* Approximately two-thirds of the energy used to power an electrical turbine generator is lost in production and transmission inefficiencies.

Table 3.21-4. California* Electricity Sales and Peak Load, 1963-1978

Year	Sales 10^9 Kwh	Growth Rate	Peak (MW)	Growth Rate
1963	67.5		13,419	
1964	75.0		14,230	
1965	80.5	8.8%	15,380	8.3%
1966	88.0		17,150	
1967	94.9		17,915	
1968	102.9		19,971	
1969	104.0		21,084	
1970	116.4		22,428	
1971	123.2	7.0%	24,873	6.9%
1972	131.4		26.475	
1973	136.5		27,480	
1974	130.3		27,555	
1975	134.6		28,389	
1976	141.6	3.2%	30,351	4.5%
1977	145.4		30,487	
1978	147.5		32,865	

Source: California Energy Commission, Energy Choices for California, Looking Ahead, Sacramento, California, March 1979.

*Includes only service areas of PG&E, SMUD, LADWP, and SDG&E. 1978 sales figures based on first ten month data and estimates for last two months, except estimate for LADWP.

Substitution might also be possible for cooking, air conditioning, and refrigeration applications; but because of heat losses, these uses would require geothermal resources with higher water temperatures than those needed for space and water heating.

Residential/Commercial End-Use Energy Consumption

Table 3.21-5 is designed to highlight those areas of the residential and commercial sectors in which there is a technical potential for end-use of geothermal energy.

The miscellaneous category, which includes lighting, appliance use, etc., is the largest user of electrical power in both the sectors. Geothermal could conceivably furnish the

Table 3.21-5. Electrical End-Use in California's Residential and Commercial Sectors (Trillion Btu)

	Residential (1978)	Commercial (1977)
Space Heating	15.4	7.8
Water Heating	21.9	3.3
Cooking	8.9	0.4
Air Conditioning	13.7	45.0
Refrigeration	49.9	14.7
Miscellaneous*	74.1	97.3

Sources: Commercial - Bob Lann, California Energy Commission, telephone conversation, March 5, 1980. Residential - Tom Gorm, California Energy Commission, telephone conversation, March 7, 1980.

*Miscellaneous includes pool heating, clothes dryers, lighting, appliances, etc.

heat for clothes drying, refrigeration and air conditioning, and pool heating. It is noteworthy that the commercial sector uses approximately four times the amount of electrical energy for air conditioning that it does for space and water heating. Energy savings in these three areas of commercial use could be significant in those communities where a suitable geothermal resource is available.

Industrial End-Use Consumption

The potential for the substitution of geothermal energy utilizing low/moderate temperature resources will be greatest for applications requiring less than 350°F (e.g., food processing, pulp and paper products, and some processes in primary metal processing). Table 3.21-6 outlines the electrical energy consumption in the industrial sector for 1976.

The potential geothermal energy contribution to meeting thermal energy requirements in California is discussed further in Section 3.3, Direct Use Applications.

TABLE 3.21-6 California Electricity Consumption in the Industrial Sector, 1976

SIC Code		10^6 KWH	% of Total
20	Food and Kindred Products	3,621.0	10
22	Textile Mill Products	231.0	1
23	Apparel, Other Textile Products	320.0	1
24	Lumber and Wood Products	1,440.5	4
25	Furniture and Fixtures	337.1	1
26	Paper and Allied Products	1,724.5	5
27	Printing and Publishing	889.9	3
28	Chemicals and Allied Products	3,272.8	9
29	Petroleum and Coal Products	5,097.7	15
30	Rubber and Plastic Products	1,521.7	4
31	Leather and Leather Products	59.0	-
32	Stone, Clay, and Glass Products	2,751.9	8
33	Primary Metals Industries	2,661.5	8
34	Fabrd Metal Products	2,074.9	6
35	Machinery, Except Electric	1,961.5	6
36	Electrical Equiopment and Supplies	2,621.6	8
37	Transportatio Equipment	3,459.0	10
38	Instruments and Related Products	584.4	2
39	Miscellaneous	265.7	1
	Total	34,887.5	100

Source: U.S. Bureau of the Census, Annual Survey of Manufacturers, 1976.

PROJECTED DEMAND AND SUPPLY

Electricity Demand Forecasting

All forecasts of energy demand and supply patterns are necessarily speculative, and energy forecasting is exceptionally difficult because of the large number of variables which affect demand. Electricity demand projections are increasingly tenuous because of unknown consumer reactions to rising prices, and variable public and corporate responses to conservation programs. Electricity supply options are uncertain because of myriad overlapping choices and constraints. Foremost among these are uncertainties concerning regulatory proceedings, economic feasibility of many technologies, health impacts, environmental impacts, and fuel availability.

Electricity demand forecasting in California represents the current state of the art. The sophisticated models developed by the CEC are unique in their level of detail. The Warren-Alquist Act of 1974 requires all California electrical utilities to submit a 20-year load forecast and resource plan to the CEC every two years. Concurrently, the CEC projects electrical demand with the Common Forecasting Methodology (CFM). The energy demand forecast ultimately adopted by the CEC is a crucial element in determining the need for and siting of future power plants. By law, an applicant who wants to build a new power plant in California must show that the project conforms with the 12-year forecast of statewide and service area electrical power demands.*

Historically, utility company forecasts have used macroeconomic forecasting techniques. Gross State Product (GSP), personal income, energy sales in the previous year, the price of electricity and natural gas, retail sales, and population growth over time are used as the key determinants of future demand.

The CFM is a microeconomic end-use model. Demand is estimated for each sector at an end-use level and then aggregated for a total system demand forecast. It forecasts sales of electricity (KWH), peak loads (MW), and reserve margins. Peak loads are of considerable concern to utility planners because of the economic consequences of electricity shortages and because peak power costs more than base-load power.**

The CEC demand projections and utility demand projections have not been in agreement. Further, both utility and CEC forecasts are being continually revised as forecasting

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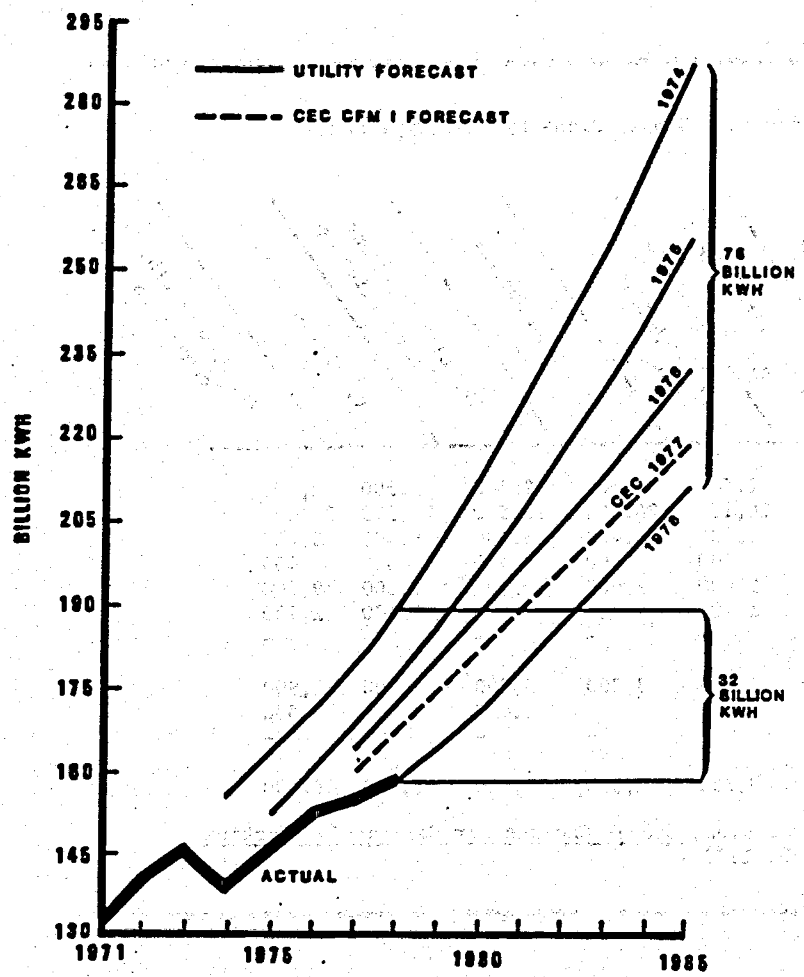
* Utility demand forecasts and facility plans are reviewed by the CEC and in public meetings every two years. Subsequently, the CEC submits a Biennial Report to the Governor and the Legislature that contains a formally adopted electricity demand forecast for the next 5, 12, and 20 years to be used for power plant siting and planning.

** The data required for this approach include: appliance saturation levels, energy use per appliance, appliance lifetimes, population estimates, commercial and industrial floorspace, building energy consumption, building fuel choice, employment levels, and specific details for industries in particular service areas. Many assumptions are also made concerning consumer preference and lifestyles. The CFM also uses hour-by-hour weather data for each of 14 different weather zones in the state. Because of the end-use data base, weather-sensitive electricity demands are estimated for different sectors.

techniques are improved and as shifting patterns of demand are identified. One example of this revision process is graphically portrayed in Figure 3.22-1.

Figure 3.22-1. California Utilities Electricity Sales



Source: California Energy Commission. Energy Choices for California, Looking Ahead, March 1979.

In 1974, the utilities projected a rapid growth rate for electricity sales. Subsequently, these utility forecasts were revised to reflect the lower demand actually experienced. A similar pattern appears in CEC forecasts.

Recent forecasts by the CEC suggest that the growth in demand for electrical energy will be substantially lower in the future.[3,4,5] While California utilities together project electricity sales growth of 3.4% annually from 1978 to 2000, the CEC forecasts average annual growth of 2.0% over the systems.

The projected demand growth rate and potential contribution of geothermal energy for these scenarios are summarized below. Tables 3.22-1, 3.22-2, 3.22-3 show the electricity supply plans, by fuel type, for all scenarios for 1985, 1990, and 2000.

Table 3.22-1. California Electricity Supply Plans by Fuel Type and Scenario, 1985 (MWe)

Fuel Source / Scenario	Present (1978)	I. Utility Supply Plans	II. High Coal Use	III. High Nuclear Use	IV. High Efficient Technologies Use	V. High Renewables Use	VI. Slow Growth, Non-combustion Tech.
Coal	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Oil/Gas	22,700	26,200	26,100	26,100	25,500	24,900	23,000
Nuclear	1,400	6,400	6,400	6,400	6,400	6,400	6,400
Cogeneration	200	400	400	400	400	400	400
Hydro	7,400	9,000	9,000	9,000	9,000	9,200	9,000
Geothermal	500	1,700	1,700	1,700	2,000	2,100	1,700
Wind, Fuel Cell Biomass, Solar	-	-	-	-	-	-	-
Transfers	3,500	3,400	3,200	3,200	3,200	3,200	2,900
Repowering	-	-	-	-	1,000	-	500
Other	-	-	-	-	-	-	-
Total	38,200	49,600	49,300	49,300	50,000	48,700	46,400

Source: California Energy Commission, Energy Choices for California, Looking Ahead, Sacramento, California, March, 1979.

In the short run (to 1985), the projected generation fuel mix and total capacity do not vary by a wide margin. For instance, projected geothermal varies from 1,700 MWe to 2,100 MWe, or about 23%, and total system capacity varies by 8% (46,400 MWe - 50,000 MWe). However, in the year 2000 (Table 3.22-3), projected thermal capacity share varies by 240% (3,500 MWe - 12,000 MWe) and total capacity varies by nearly 65% (50,000 MWe - 82,600 MWe) among the six scenarios.

1. Utility Supply Plans

According to utility company plans, between 1979 and 1991, the combined generation system capacity is projected to increase at 3.9% per year, and at 2.9% per year between same time period. In addition, the CEC estimates that peak demand will grow at 1.8% per year, although utilities project peak demand growth at 3.2% per year. Figures 3.22-2 and 3.22-3 represent recent CEC staff demand estimates. Comparing Figures 3.22-3 and 3.22-2 with Figure 3.22-1, it is apparent that estimates have changed dramatically between 1974 and 1979.

Table 3.22-2. California Electricity Supply Plans by Fuel Type and Scenario, 1990 (MWe)

Fuel Source / Scenario	Present (1978)	I. Utility Supply Plans	II. High Coal Use	III. High Nuclear Use	IV. High Efficient Technologies Use	V. High Renewables Use	VI. Slow Growth, Non-combustion Tech.
Coal	2,500	7,300	11,800	7,900	6,000	6,000	4,600
Oil/Gas	22,700	26,900	26,200	26,200	25,000	25,800	21,800
Nuclear	1,400	7,800	7,800	11,800	7,800	7,800	6,600
Cogeneration	200	500	1,300	1,300	2,700	1,300	1,300
Hydro	7,400	9,100	9,100	9,100	9,100	9,700	9,100
Geothermal	500	2,700	2,700	2,700	2,700	3,600	2,700
Wind, Fuel Cell	-	-	-	-	-	100	100
Biomass, Solar	-	500	500	500	500	600	400
Transfers	3,500	3,000	2,700	2,700	2,700	2,700	2,700
Repowering	-	-	-	-	5,200	1,800	600
Other	-	4,800	-	-	-	1,000	-
Total	38,200	62,600	62,100	62,200	61,700	60,400	49,900

Source: California Energy Commission, Energy Choices for California, Looking Ahead, Sacramento, California, March, 1979.

Projected Electrical Power Supply

In this section, six scenarios of electrical energy generation fuel mix to the year 2000 are described. Three additional scenarios which consider different time horizons and utility service are summarized in subsequent text. The first six scenarios were constructed by the CEC to address supply options that are frequently mentioned in energy debates.

The first strategy considered by the CEC is the current supply plan of the utility companies. The next four strategies are based on utility demand growth projection of 3.6%

Table 3.22-3. California Electricity Supply Plans by Fuel Type and Scenario, 2000 (MWe)

Fuel Source / Scenario	Present (1978)	I. Utility Supply Plans	II. High Coal Use	III. High Nuclear Use	IV. High Efficient Technologies Use	V. High Renewables Use	VI. Slow Growth, Non-combustion Tech.
Coal	2,500	9,600	37,800	7,900	16,300	11,100	5,500
Oil/Gas	22,700	24,500	18,800	18,800	13,700	19,100	18,000
Nuclear	1,400	11,100	7,800	38,400	7,800	7,800	7,800
Cogeneration	200	500	1,300	1,300	8,000	2,800	2,800
Hydro	7,400	9,000	9,000	9,000	11,400	12,000	9,800
Geothermal	500	3,500	3,500	3,500	3,500	12,000	8,000
Wind, Fuel Cell Biomass, Solar	-	1,000	1,000	1,000	3,000	9,000	4,500
Transfers	3,500	2,700	2,700	2,700	2,700	2,700	2,700
Repowering	-	-	-	-	7,200	3,000	1,100
Other	-	14,800	-	-	3,000	3,000	-
Total	38,200	76,700	81,900	82,600	81,600	82,500	60,200

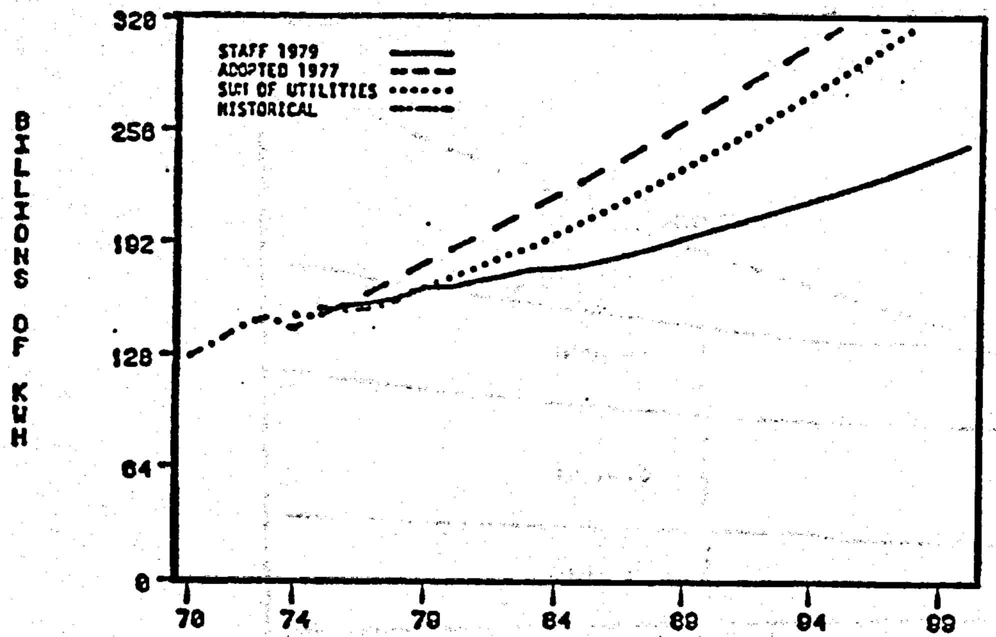
Source: California Energy Commission, Energy Choices for California, Looking Ahead, Sacramento, California, March, 1979.

per year and four different supply mixes. They are:

- high coal use, emphasizing new baseload coal plants;
- high nuclear use, emphasizing new baseload nuclear units;
- maximum use of existing facilities and sites with heavy dependence on cogeneration and repowering;
- maximum use of nonconventional resources, other than those which are demand-reducing.

The sixth strategy assumes a slower demand growth of 2% per year, due to demand-reducing policies and maximum use of nonconventional resources. The seventh strategy identifies a nuclear-based electrification program. The eighth strategy, developed for only one utility company (PG&E) by the Environmental Defense Fund (EDF), considers only nonconventional resources. Finally, the last strategy (Distributed Energy Systems) addresses the supply issue on a fifty-year scale with an emphasis on distributed, renewable energy

Figure 3.22-2. Sales Forecast Comparison Statewide



Source: California Energy Commission. <u>California Energy Demand, 1978-2000</u>, August 1979.

1991 and 1998. Geothermal is expected to rise from the current 1% of capacity to 5% by 1998.

2. <u>High Coal Use</u>

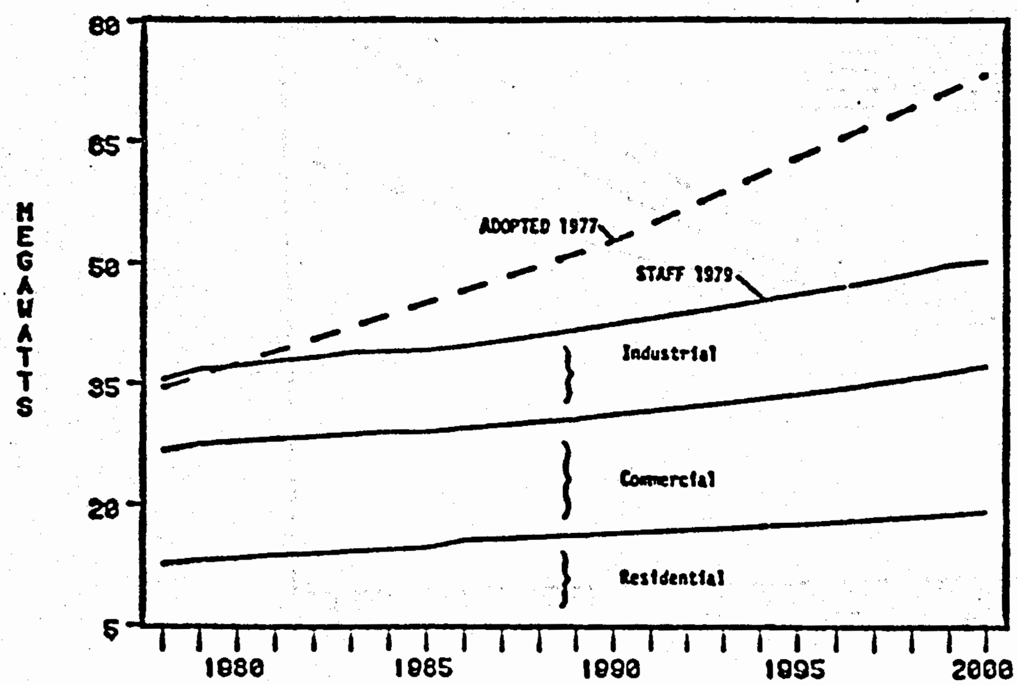
In the high coal use scenario, total energy supplies increase by approximately 2% per year between 1979 and 1991. Since baseload coal facilities do not come on-line until the late 1980's, it is not until 1992-2000 that energy supplies increase at over 4% per year. During this 20-year period, geothermal energy increases from one to four percent of total electricity supplies.

3. <u>High Nuclear Use</u>

Total energy gowth rises slowly, about 2% per year, between 1979 and 1991 and then shoots up to about 4% in 1992-2000 when a nuclear power plant could come on-line. Geothermal, as in the other two scenarios, rises from one to five percent of electricity generation capacity by 2000.

4. <u>High Use of Efficient Combustion Technologies</u>

Figure 3.22-3. Statewide Peak Demand



Source: California Energy Commission. California Energy Demand, 1978-2000, August 1979.

The fourth scenario "uses an efficiency-oriented supply strategy-- attempting to reduce or avoid the regional equity concerns related to rural siting by increasing the useful output from existing generation and transmission facilities, and more extensive use of areas already dedicated to industrial uses."[6] In this case, the supply of energy grows by approximately 2% per year between 1979 and 1991 and by approximately 4% in 1992-2000, due to new dam operation and upgrading of old sites, plus a switch to coal or petroleum coke-derived fuels as an energy source. Geothermal development is not accelerated because it would require development of new sites, usually in rural areas.

5. High Use of Renewable Resources

The nonconventional resource case "examines the feasibility of using renewable resources (including solar, wind and hydro) and geothermal energy to meet California's electricity requirements...."[6] In this scenario, it is assumed that geothermal energy development is accelerated to supply 12,000 MW of capacity, or 15% of electricity supply, by 2000. Total energy growth averages less than 2% per year between 1979 and 1991 and rises to over 4% during the 1992-

2000 year period.

6. Slow Demand Growth, High Use of Non-Conventional Alternatives

This strategy explores the electricity supply planning implications of a substantially less demand growth than that projected by the utilities (i.e., 2% per year), due perhaps to demand-reducing policies. Most of the new capacity in this case is supplied by geothermal resources. 8,000 MWe of geothermal energy, or 13% of total capacity, are assumed to be developed by 2000. During the 1979-2000 period, oil facilities are retired at a rate dependent on the availability of technologies using renewable fuels. Between 1979 and 1985, total growth in energy averages just over 3% per year; between 1985-1991 it falls to under 2% per year, and rises in 1992-2000 to 4% per year.

7. Nuclear-Based Electrification

The strategy of nuclear-based electrification is intended to displace oil and gas use in the state very quickly by shifting to electricity and eliminating most of the large oil and gas-fired plants now in service.

8. EDF Alternate PG&E Supply Plan [7]

Relying on the utility demand forecast, the Environmental Defense Fund developed a supply strategy for one utility, PG&E, that could potentially be applied statewide. A methodology, called "efficiency maximizing," was used to maximize cost-effectiveness and minimize financial risk subject to PG&E's financial and revenue requirements. The selected options were: (1) end-use application of solar energy for space and water heating; (2) measures to increase end-use efficiencies; and (3) development of electrical generation technologies that are energy efficient or are powered by renewable resources. Geothermal development increases to produce 23% of PG&E's electricity (from 8%).

9. Distributed Energy System [8,9]

The last case is based on a Lawrence Berkeley Laboratory (LBL) scenario. It considers the end-use of energy, rather than its source. A major premise of this end-use perspective is that centrally produced electricity should be used only as necessary to satisfy demand, but other sources, such as solar heat or direct fuel use, should be substituted where the quality energy represented by electricity is not necessary. The intent of this strategy is to move California from using hard technologies (defined as conventional technologies, such as coal, oil, gas, and nuclear fission) to soft technologies (defined as those that are flexible, resistent, sustainable, and benign) through transitional technologies which include cogeneration, biomass, and sophisticated use of coal.

The major conclusion of the LBL report is that under the stated assumptions, it is nearly possible to supply California's energy demand with indigenous, renewable resources. (The authors note that indigenous supply of liquid fuels may not be sufficient for the transportation demand.) Based on their comparison of the present marginal cost of all fuel sources and the projected cost of new conventional supply sources, the report concluded that it would be cheaper for the consumers and the utilities to use renewable resources than to use conventional technologies.

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3.3 DIRECT USE OF GEOTHERMAL RESOURCES

Heat from geothermal energy can be utilized directly for a particular application, rather than being converted to some other form of energy (mechanical or electrical) before use. Common examples of such applications include residential space conditioning, district heating, and industrial processing. There are now approximately ten geothermal direct-use projects (not including spas and resorts) in California. These projects include heating greenhouses, warming water for catfish and prawn farming, and space and water heating. Several larger projects, such as district heating systems and process heating for industrial parks, are under consideration. A list of current and potential applications can be found in Section 2.22.

Data for thermal energy requirements by sector are presented in Table 3.1-1. Note the large demand for thermal energy in the residential and industrial sectors*. Geothermal development to meet residential thermal demand may be inhibited because of the low load factors for space heating and the low populations in geothermal areas. However, as conventional fuel prices escalate, industry may turn to geothermal to fill a larger portion of its thermal requirements.

INDUSTRIAL ENERGY DEMAND

Required temperatures for various industrial applications are given in Figure 3.3-1. The figure also indicates whether the energy is supplied as steam or hot water.

California industry thermal requirements are listed by 3-digit Standard Industrial Classification (SIC) code in Table 3.3-1.

According to Jet Propulsion Laboratory estimates, the 33 highest energy consuming industries in California accounted for approximately two-thirds of the total thermal energy use in 1975 and the top ten accounted for nearly one-half. Required temperatures may range from 40°F to over 2,000°F depending upon the end-use. Where the required temperature is above 350°F, it is usually above 1000°F.**

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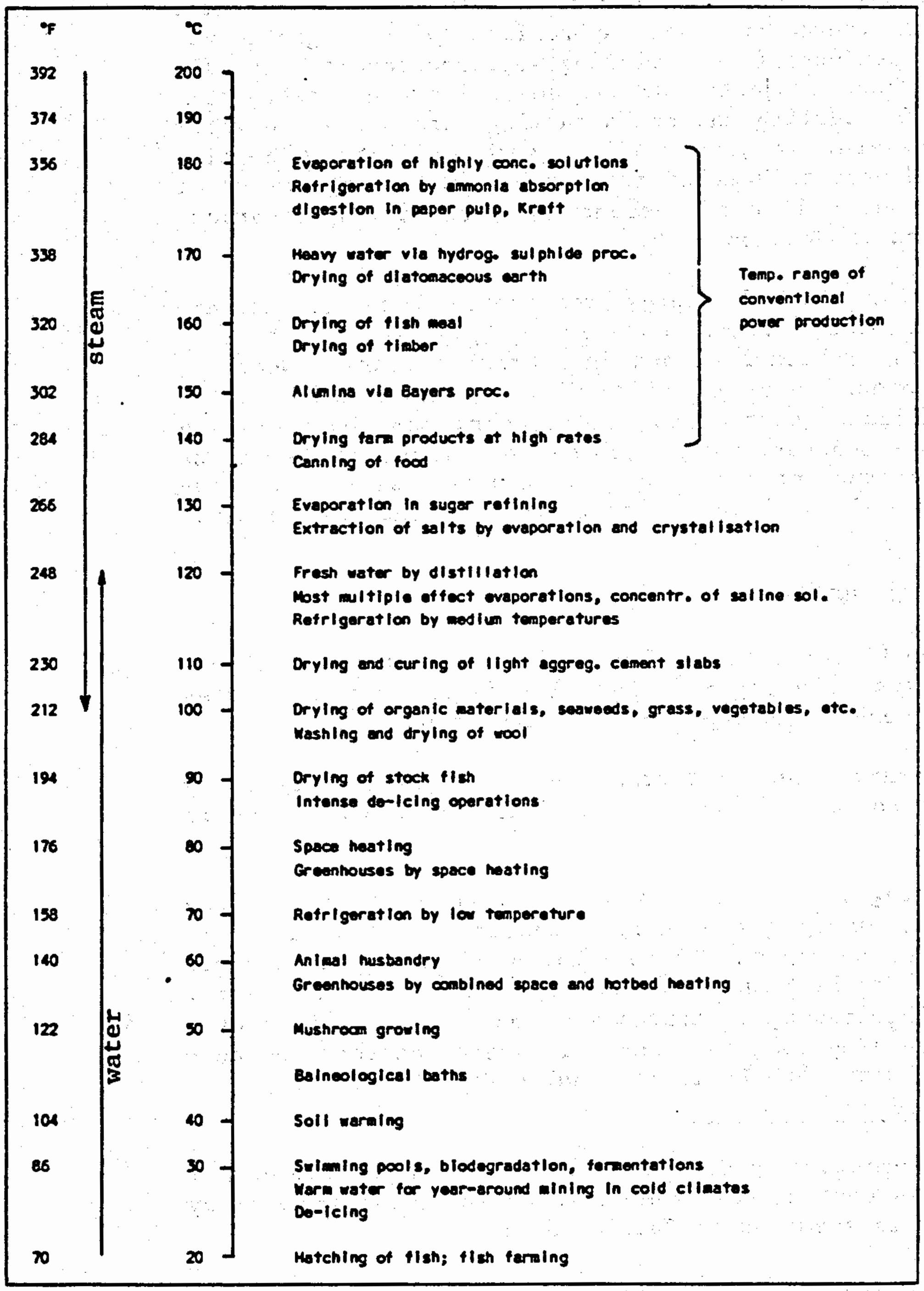
*The technical potential for substituting geothermal heat for residential and commercial users now supplied by electricity is examined in Section 3.21.

**These industries include petroleum refining, organic chemicals, cement, and blast furnaces. Lower temperature needs in these industries are either very small or are met with waste heat from higher temperature operations.

Figure 3.3-1. Required Temperature of Geothermal Fluids for Various Direct Heat Applications.



Source: Geothermal Resources Council, Direct Utilization of Geothermal Energy: A Technical Handbook, edited by D. H. Anderson, Geothermal Resources Council, and J. W. Lund, Oregon Institute of Technology, 1979.

Table 3.3-1. Thermal Energy End-Use Requirements of Top Thermal Energy Consumers by 3-Digit SIC Code, California, 1975

THERMAL ENERGY RANK	SIC CODE	CLASSIFICATION	THERMAL ENERGY CONSUMPTION 10^{12} BTU	Thermal Energy End Use Requirements[a] Under 212°F 10^{12} BTU		212°F to 350°F 10^{12} BTU		Over 350°F 10^{12} BTU	
				10^{12} BTU	% of Total Thermal	10^{12} BTU	% of Total Thermal	10^{12} BTU	% of Total Thermal
1	291	Petroleum Refining[b]	168	0	0	8.4	5	160	95
2	281	Industrial Organic Chemicals	56	0	0	0	0	56	100
3	324	Hydraulic Cement[b]	45	0	0	.9	2	44.1	98
4	331	Blast Furnaces[b]	31	0	0	0	0		100
5	206	Sugar Products	23	5.0	22	16.8	73	1.2	5
6	203	Preserved Vegetables/Fruits[c]	22	16.9	77	3.7	17	1.3	6
7	322	Glassware[b]	18	0	0	0	0	18.0	100
8	327	Concrete and Allied Products	16	1.0	7	2.1	13	12.8	80
9	263	Paperboard Mills	15	5.0	33	10.0	67	0	0
10	209	Miscellaneous Food Products	12	9.0	75	3.0	25	0	0
11	329	Nonmetallic Minerals	8	0	0	2.0	25	6.0	75
12	335	Nonferrous Rolling Mills	8	0	0	2.0	25	6.0	75
13	325	Structural Clay[b]	8	0	0	0	0	8.0	100
14	208	Beverages[c]	7	2.2	31	12.9	41	1.9	28
15	262	Paper Mills[c]	7	2.0	33	5.0	67	0	0
16	289	Miscellaneous Chemical Products	7	0	0	5.2	75	1.8	25
17	371	Vehicle Manufacturing	7	3.5	49	1.1	16	2.4	34
18	282	Plastics	6	1.7	29	2.9	48	1.4	23
19	242	Sawmills[b]	6	3.0	50	3.0	50	0	0
20	202	Dairy Products[c]	5	4.3	86	0.1	2	0.6	12
21	339	Miscellaneous Metal Products	5	0	0	0	0	5.0	100
22	372	Aircraft Manufacture	5	0	0	0	0	5.0	100
23	344	Structural Metal	4	0	0	0	0	4.0	100
24	301	Tires	4	0	0	4.0	10	0	0
25	295	Paving/Roof	4	0	0	3.8	96	0.2	4
26	284	Soap	4	2.9	72	1.0	26	0.1	2
27	201	Meat Products[c]	4	3.9	98	0	0	0.1	2
28	205	Bakery Products[c]	4	0.5	12	0	0	3.5	88
29	332	Iron and Steel	4	0	0	0	0	4.0	100
30	265	Paper Containers	3	0	0	3.0	100	0	0
31	347	Metal Coating, Engraving[c]	3	1.5	50	0	0	1.5	50
32	204	Grain Mill Processing[c]	3	0	0	3.0	100	0	0
33	307	Miscellaneous Plastics	3	0	0	3.0	100	0	0

Source: A.D. Little, Inc., Energy Shortage Contingency Plan: Technical Appendix, A Report for the California Energy Resources Conservation and Development Commission, October 1975.

Notes: (a) Thermal end-use temperature breakdown is adapted from data in Intertechnology Corporation (ITC), Analysis of the Economic Potential of Solar Thermal Energy to Provide Industrial Process Heat, Final Report, Volume 1, II, Washington, D.C., Government Printing Office, February 1977, with modifications based on this California survey effort. (b) Industries with processes where excess low-temperature thermal energy appears to exist or wasteheat appears to be available. (c) Industries in which on-site visits were made.

Table 3.3-2. Process Heat Requirements for Selected Industrial Applications by Standard Industrial Classification Code, 1974.

SIC Code	Classification	Application Temperature Requirement (°F)	Medium
20.	Food and Kindred Products		
2011	Meat Packing		
	Scalding, Carcass Wash, and Cleanup	140	Hot Water
	Singeing Flame	500	-
	Edible Rendering	200	-
2013	Meat Processing		
	Smoking/Cooking	155	Hot Air
	Cleanup	160	Hot Water
2026	Fluid Milk/Ice Cream		
	Pasteurization	162-185	Steam
	Truck/Tank Wash	110-170	Hot Water
	Cleanup	160-180	Hot Water
2033	Canned Fruits and Vegetables		
	Blanching/Peeling	180-212	Hot Water/Steam
	Pasteurization	200	Hot Water
	Brine Syrup Heating	200	Steam
	Commercial Sterilization	212-250	Steam/Hot Water
	Sauce Concentration	212	Steam
	Can Washing	180-190	Hot Water
2037	Frozen Fruits and Vegetables		
	Blanching	180-212	Steam/Hot Water
	Warehouse Floor Heating	90	Hot Water/Hot Air
2048	Prepared Feeds		
	Pellet Conditioning	180-190	Steam
	Alfalfa Drying	400	Hot Air
2051	Bread and Baked Goods		
	Sponge Mixing	75	Warm Air
	Proofing	105-115	Steam Heated Air
	Baking	400-425	Hot Air
	Cleanup-Basket Washing	165	Hot Water
2079	Shortening and Cooking Oil		
	Seed Conditioning	180	Steam
	Stack Cooker	280	Steam
	Oil Storage	100-120	Steam
	Fatty Acid Removal	180	Steam
	Vacuum Bleaching	220	-
	Hydrogenation	380	Steam
	Deodorization	500	-
2082	Malt Beverages		
	Cooker	212	Steam
	Water Heater	180	Steam
	Mash Tub	170	Steam
	Grain Dryer	400	Steam
	Brew Kettle	212	Steam
	Can/Bottle Washing	140-160	Hot Water
	Can Pasteurization	145	Hot Water

Table 3.3-2 continued.

SIC Code	Classification	Application Temperature Requirement (°F)	Medium
20.	Food and Kindred Products		
2086	Soft Drinks		
	Fructose Storage	90	Steam
	Returnable Bottle Washing	170-190	Hot Water
	Can Warming	130-140	Hot Water
	Cleanup	140-170	Hot Water
24.	Lumber and Wood Products		
2421	Sawmills		
	Kiln Drying of Lumber	110-180	Hot Air
26.	Paper and Allied Products		
2621	Paper Mills		
	Pulping	120-180	Hot Water
	Paper Drying	290-600	Steam
28.	Chemicals and Allied Products		
2841	Soaps and Detergents		
	Soaps (Mazzoni Process)		
	Fatty Acid Preheat	130	Steam Jacket
	Mixing Tank	180	Steam Jacket
	Dryer		Steam
	Detergents		
	Crutcher (Mixer)	180	Steam
	Spray Dryer	500	Hot Air
34.	Fabricated Metal Products		
3479	Galvanizing		
	Metal	130-180	Electric Coils
	Galvanizing Plating Baths	850	-
49.	Electric Gas and Sanitary Services		
	Sewage Treatment		
	Sludge Digesters		
	Mesophyllic	95	Steam
	Thermophyllic	120	Steam

Source: A.D. Little, Inc., Energy Shortage Contingency Plan: Technical Appendix, A Report for the California Energy Resources Conservation and Development Commission, October 1975. As adapted from Intertechnology Corporation (ITC), Analysis of the Economic Potential of Solar Thermal Energy to Provide Industrial Process Heat, Final Report, Volume I, II, Washington, D.C., Government Printing Office, February 1977.

The top energy consuming industries with temperature requirements under 212°F are primarily in the food processing industry. The energy is used to heat products, to heat water for cleaning, and to heat air for dehydration of products. The paper products, metal plating, and soap industries also have most of their process temperatures below 212°F. Even when the process temperature is relatively low (below 150°F), it is common to find the heat supplied through a boiler producing steam of 350°F.[1]

Process heat requirements at the 4-digit SIC code level for California industries are shown in Table 3.3-2. Note the large energy requirements for food processing.

Even when no major technical problems impede the transition to new industrial fuel sources, the existing fuel choice requires a significant and unique capital investment which tends to slow the fuel switching process. Thus, conversion to an alternative energy source in any industrial plant or company will normally occur when only one or more of the following conditions exist:[2]

- Use of new energy source provides a return on investment sufficiently attractive to compete for the capital required for new facilities.
- Production expansion occurs so that a new energy source may be incorporated on the basis of long-term expectations.
- Fuel availability or regulatory restrictions force a change in fuel use.

These market issues are further explored in Section 4.3.

REFERENCES

1. Jet Propulsion Laboratory, Process Heat in California; Applications and Potential for Solar Energy in Industrial Agricultural, and Commercial Sectors, JPL 78-33, Pasadena, CA, March 1978.

2. Dow Chemical Company, Evaluation of New Energy Sources for Process Heat, Midland, Michigan, 1975.

RESOURCE PROFILE
DEVELOPMENT ACTIVITIES
ENERGY SUPPLY and DEMAND

4. GEOTHERMAL ENERGY MARKET

GOVERNMENT ACTIVITIES and INITIATIVES
PRIVATE SECTOR ACTIVITIES
SIGNIFICANT EVENTS

SECTION 4: GEOTHERMAL SHARE OF THE CALIFORNIA ENERGY MARKET

This section examines some general considerations affecting the commercialization of geothermal energy in California.

Section 4.21 summarizes present development plans for geothermal electric and CEC projections. The economic risks of field development and power plant construction for developers and utilities are reviewed; a brief description of current technologies for electric power generation and H_2S abatement is included for the reader's reference. Following this discussion, the most salient technical, economic, environmental, and institutional issues at individual sites are examined in Section 4.22 to suggest possible policy initiatives.

Data on the potential market share for direct heat applications is very limited at present. Section 4.3 will review the historical development of direct use projects and investment issues. Potential locations for various direct applications are highlighted by county.

4.1 GENERAL CONSIDERATIONS AFFECTING GEOTHERMAL DEVELOPMENT

The present political and economic climate for geothermal development in California is very favorable.

Geothermal energy is considered attractive as a source of baseload* electric power because a large resource potential has been identified. At The Geysers, vapor-dominated resources already generate sufficient electricity to meet the requirements of the City of San Francisco. In the Imperial Valley, a number of utilities are participating in the development of hot-water resources. Over the long term, it may be possible to use geothermal power plants to meet baseload requirements, relegating high cost fossil plants to peakload uses.

Second, because of the relatively small scale of a geothermal power generating plant, smaller utilities and developers can afford to undertake electricity production. This is an important entry condition as organizations like the California Department of Water Resources and the Northern California Power Association are encouraged to establish their own generation capacity rather than continue to rely on supplies from the larger utilities.

Third, the pricing structure for geothermal steam is relatively more stable than that for conventional fuels. Prices at The Geysers are presently an "average" price, determined by a mix of other fuel sources, for a unit of geothermal steam. This is advantageous to the developer because the cost of producing geothermal steam is less than the cost of producing steam from conventional fuels. The benefit to the utility (PG&E) is that geothermal steam at The Geysers displaces more costly fuel oil. Whether liquid-dominated resources will share this pricing advantage depends upon technology costs and regulatory actions.

Fourth, geothermal is considered a "preferred alternative" energy source by the State Legislature and the California Energy Commission (CEC), partly because it is generally seen as more environmentally acceptable than conventional alternatives. Power plant siting requirements and procedures are therefore relaxed for geothermal facilities.

Direct heat application of geothermal energy may also expand the geothermal share of the California energy market by meeting heat requirements now being supplied by other energy sources. Direct use of geothermal energy generally implies the use of much less complicated technologies, less

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* To utilize the producing wells most efficiently, geothermal power plants need to run almost continuously.

capital-intensive development efforts, and a number of diverse applications. However, present development of direct utilization in California, and in the U.S. in general, lags behind similar efforts elsewhere in the world, notably Iceland. This may be due to the historical availability of cheap energy and the lack of public awareness of direct use of geothermal energy as an economical alternative to conventional energy systems. This situation should change as more resources are proven and thermal energy users become more familar with geothermal energy.

Development of geothermal resources may involve significant social, economic, or environmental impacts for local communities. The local community is often where the trade-offs among national energy policy, state regulatory concerns, and local land use issues are made. The acceptance of energy resources development by local communities is an important factor in the siting of geothermal facilities. In electric power production, the end-use beneficiaries of geothermal development may reside outside the producing area, while the environmental and social impacts of power production are borne by the community. In the case of direct heat applications, the community retains more of the benefits in the form of taxes, added employment opportunities, and economic availability of a source of fuel. Thus, depending on the balance of costs and benefits, individual localities may prefer direct applications as an inducement to economic development. However, development of geothermal resources for electricity generation can also improve the economic environment for direct use in certain remote areas by assuming the costs of resources confirmation and additional service infrastructure in the community.

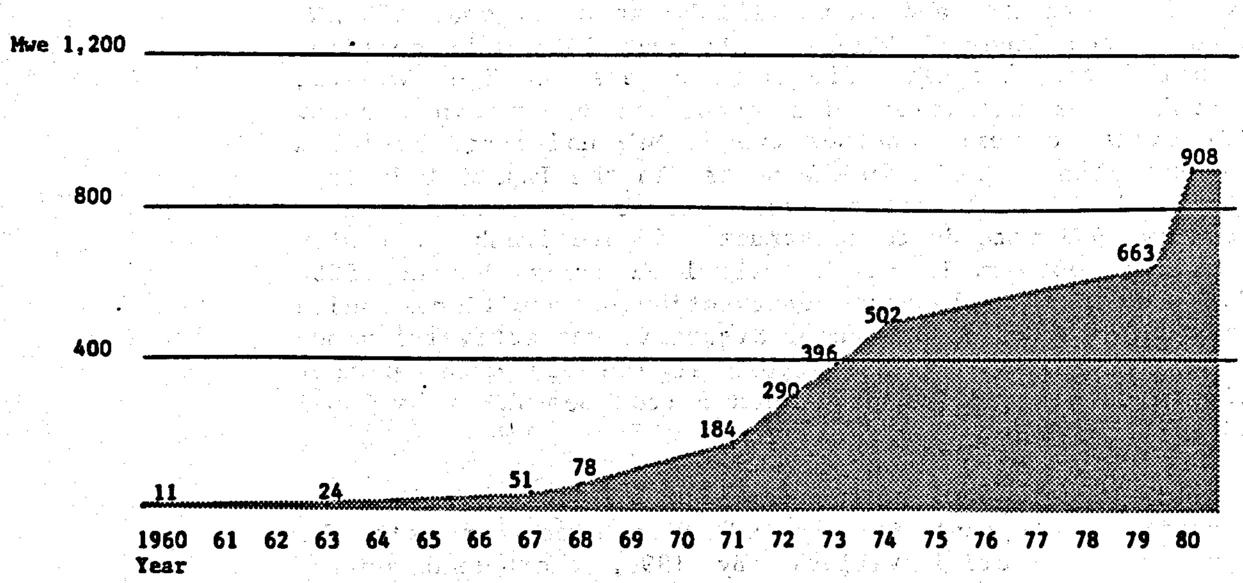
While the analysis of benefits and costs must be made at each site, state and federal agencies can facilitate the balancing process by transferring planning and evaluation capabilities to local bodies. State and federal agencies may also provide incentives to change the actual balance at a particular location by mitigating problems, compensating costs, or amplifying benefits. Government initiatives can also be applied to change the calculations by utilities and potential developers. Programs may reduce uncertainties or insure risks, or increase the potential profits of successful developments. The most salient issues at individual sites are discussed in Sections 4.2 and 4.3; general governmental programs are discussed in Section 5.

4.2 ELECTRIC APPLICATIONS

4.21 GEOTHERMAL SHARE OF THE ELECTRIC MARKET

The historical focus of the geothermal-electric industry in California has been on the dry steam development of The Geysers KGRA. As of June 1980, there are 798 MWe on-line at The Geysers.* This constitutes approximately 1% of the present installed electricity generation capacity in California. Figure 4.21-1 illustrates that geothermal capacity has grown at nearly a 40% yearly rate since 1960 (i.e., a doubling time of about two years).

Figure 4.21-1. Geothermal Electric Capacity at The Geysers



Source: California Energy Commission, Geothermal Energy Updates, March 5, 1980.

Development activities are continuing in The Geysers region and at other KGRAs around the state. It is reasonable to expect that there will be significantly expanded development of geothermal reserves in the future. Siting and construction of fossil fuel and nuclear power plants are problematic in California, and utilities are actively pursuing the development of non-conventional resources, including geothermal. Various projections of the potential for geothermal-electric generation have been made.[1,2,3,4]

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*On May 15, PG&E Unit 13 began generating full power at The Geysers. A 110 MWe power plant, Unit 14, is expected to be on line by August 1980.

However, in this section only the utility company forecasts and California Energy Commission estimates are used.*

Through 1982, it is expected that 617 MWe of additional electric capacity will be provided by geothermal energy. The Geysers should provide about 60% of the increase, with the Imperial Valley KGRAs contributing the balance. Besides PG&E at The Geysers, the Northern California Power Agency (NCPA) with Shell expects to have two 55 MWe units on-line by the end of 1982. In Imperial Valley, SDG&E and SCE each will have three plants on-line by 1982. SCE's largest plant will be a 50 MWe double flash unit, while SDG&E will have a 50 MWe flash turbine.

After 1982, development will continue in both The Geysers and Imperial Valley.** By 1985, The Geysers will have 506 more MWe and there will be an additional 433 MWe added in the Imperial Valley. Although PG&E will continue to build the largest (110 MWe) plants in The Geysers, several other utilities will construct their own plants. NCPA plans to build another two 33 MWe units and both DWR and SMUD plan to build 50 MWe units. In the Imperial Valley, SDG&E and SCE will each construct three new plants. Additionally, DWR intends to construct a 55 MWe flash plant with McCulloch Geothermal and Geothermal Kinetics. Beyond 1985, PG&E and SMUD is planning construction of additional units (five 110 MWe units and one 55 MWe unit, respectively) pending availability of steam supply at The Geysers. Another 350 MWe is planned for Heber and Salton Sea KGRAs by SDG&E and SCE in the Imperial Valley.

In Figure 4.21-2, cumulative projected geothermal-electric development is plotted over time for both The Geysers and Imperial Valley. By 1990, geothermal energy will provide approximately 2,566 MWe of additional electric capacity. This corresponds to a yearly growth rate of 14% or about a five-year doubling time.

It is difficult to speculate as to what level geothermal-electric capacity eventually will reach. In Table 4.21-1, an estimate of the potential resource electric capacity is shown. The total estimated capacity is 13,816 MWe.

While it is not reasonable to expect that all of the resource will be developed, it is interesting to observe

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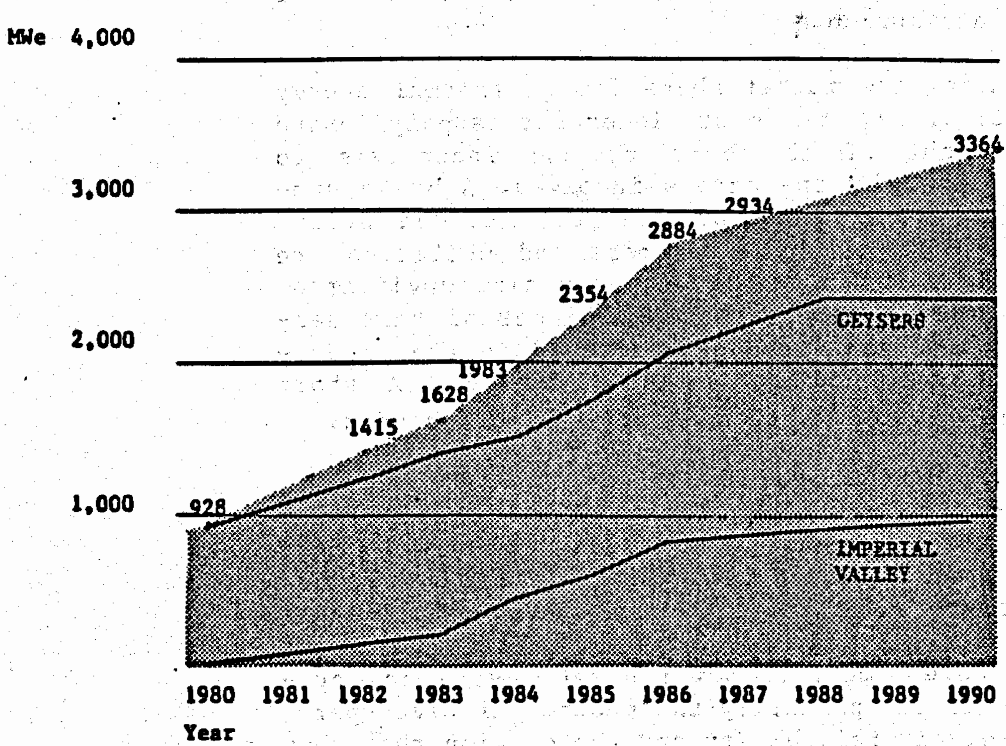
* CEC projections of geothermal market share are presented along with utility commitments for newer power plants. Data sources are utility submissions to the CFM II and various CEC publications.

** CEC, 1979 projections.

Figure 4.21-2. Projected Geothermal Electric Capacity



Source: California Energy Commission, Geothermal Energy Updates, March 5, 1980.

Table 4.21-1. Identified Potential of Known Geothermal Resource Areas

Area	Electrical Energy (MWe/30 yrs.)
The Geysers	1,610
Surprise Valley Area	1,490
Morgan Springs Growler Springs	116
Sulphur Bank Mine	75
Clear Lake Volcanic Field Area	900
Long Valley Caldera	2,100
Coso Area	650
Randsberg Area	84
Salton Sea Area	3,400
Westmorland	1,710
Brawley	640
East Mesa	360
Border	31
Heber	650
Total	13,816

Source: USGS, Assessment of Geothermal Resources of the United States, Circular 790, 1978.

that market projections for geothermal-electric to 1987 estimate an installed capacity of 3,300 MWe, or about 24% of the potential contribution.*

When evaluating the market share for geothermal energy sources in California, we must interpret supply/demand information in light of the barriers and incentives to development perceived by the actors involved. A brief summary of the field development process is provided below. Various risks encountered by developers and utilities are characterized according to technical, economic, environmental, and institutional issues. The remainder of this section describes the present technologies used in the production of both steam and hot water resources. A short description of H_2S abatement technology is also included.

FIELD DEVELOPMENT FOR ELECTRIC POWER

The lead time and financial resources needed to bring a geothermal electric development on line are substantial. The typical first on-site geothermal development moves sequentially, rather than concurrently, from reservoir exploration and development to power plant design and construction. This is due primarily to geothermal developers' concern with reservoir reliability and the caution they show in risking capital development in a new technology.

The pattern of geothermal electric development at The Geysers has been to start with small units (12 MWe) and gradually increase unit size and installed capacity as reservoir performance is better defined. Development at other geothermal resource areas can be expected to follow a similar pattern. Table 4.21-2 provides an estimate of the implementation time frame for California power plants as of March 1979.

Developer Risks

The developer must establish the size and productivity of the reservoir. If the developer cannot provide assurances to the utility that the reservoir can support power plants of a stated size and capacity, then he is in a poor bargaining position.

Technological/economic issue: Presently, there are no low cost, high confidence techniques for identifying, characterizing, and proving the extent and capacity of a

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* It is important to keep in mind that estimates of potential geothermal-electric capacity are continually being revised as new fields are discovered and reservoir estimation is refined.

Table 4.21-2. Approximate Implementation Time for Geothermal Power Plants*

Area	Reservoir		Power Plant	
	Exploration: -planning/leasing -EIR/permits -drilling/testing	Development: -permits -drilling/testing of production wells	Design and Development: -planning/concept design -detailed design and permitting	Construction: -site/facilities/equipment installation and testing -transmission tie-in
Geysers Steam				
PG&E 17 & 18 (110 MWe Plants)	2½ yr	3¼ yr	~2 yr	2½-3 yr
DWR Bottlerock	2 yr	2½ yr	2¼ yr	2¾ yr
DWR South Geysers	-	3½ yr	2¾ yr	2½ yr
Imperial Valley				
Heber	-	2½ yr	2 yr	2 yr
East Mesa	2½ yr	6½ yr	1½ yr	2¼ yr
Salton Sea	3¾ yr	3½ yr	2¼ yr	2½ yr
Brawley	3 yr	2½ yr	2½ yr	2 yr
Westmorland	-	6 yr	2 yr	2½ yr
Mono-Long Valley	3¼ yr	2¾ yr	5½ yr	2¼ yr
Coso Hot Springs	2¼ yr	3 yr	2 yr	2¼ yr
Wendell-Amadee	2¾ yr	2¾ yr	3¾ yr	2½ yr

Source: Systems Development Corporation, Regional Systems Development for Geothermal Energy Resources - Pacific Region, Task I - Implementation Plan Development, Santa Monica, Ca., 26 March 1979, Figures 5-4, 5-14, 5-24, 5-25, 5-27.

* Estimates are for a nominal 50 Mwe plant unless otherwise noted.
**Assumes a cogeneration design.

geothermal anomaly. The technique most often relied upon is construction and operation of a pilot plant for a short period of time. Suggestions have been made that the development of a portable, modular, 1-5 MWe generating unit would aid in quickly demonstrating the potential capacity of liquid-dominated geothermal resource.[5]

Economic issue: Exploration and field definition activities require substantial financial backing for the developer, and require revenues commensurate with the size of its resource investment.[6] The investor must be capable of sustaining the initial development period without receiving any return, because there can be no return on investment until a utility contracts for steam or hot water. For these reasons a number of geothermal developers are capital intensive oil companies (Shell, Union, Chevron, Phillips, etc.) A major concern for independent companies is availability of venture capital for exploration activities.

Utility Risks [7]

The key factors considered by utilities in the selection of an energy source are fuel cost and reliability. The risks associated with the development of a geothermal power plant are those concerned with (1) the resource, (2) production operations, (3) regulation, and (4) public intervention. Technical and economic uncertainties are predominant in the first two risks, while exposure to environmental and institutional issues characterize the latter.

o Resource Risk

Technological/economic issues: To fully develop a geothermal reservoir for the production of electricity, the utility may have to invest $60 million.* Prior to making a decision to construct a geothermal power plant, utilities must evaluate whether the energy supplied by the geothermal resource is reliable, and how well the fuel cost can be estimated. The resource risk perceived by utilities is a function of the confidence they have in existing resource assessment and reservoir engineering capabilities. However, to the extent that reservoir failure is an "insurable risk," the availability of reservoir insurance may provide a method of factoring the risk into the cost of geothermal electricity production.**

o Risk from Production Operations

Technological/economic issues: Given the nature of the resource, geothermal resources are most suited to baseload or intermediate baseload operation. Utilities must consider whether geothermal plants will complement existing generating sources to provide high reliability for the grid with adequate reserve. Some plants at The Geysers have had load factors as high as 90%. If, as a result of operation difficulties, the plant were to be available for a much lower percentage of time, or had lower output, or shorter useful life, the utility would face a load planning problem. For a small utility, obtaining large blocks of replacement baseload power supplies at short notice and high cost would be extremely disruptive. A suggested measure is to match initial unit output to available excess capacity on nearby transmission lines.

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*A general estimate of the costs of bringing a geothermal electric development on-line can be made from Table 6.1-2, which presents PG&E's capital investments in The Geysers steam field. (Hydrothermal power plant developments in the Imperial Valley will be somewhat more expensive.)

**See Section 6.4 for a description of reservoir insurance proposals in the private sector.

Another economic issue is the availability of transmission facilities. Delays in the acquisition of necessary rights-of-way and uncertainties in construction costs can affect the economic viability of a project.

- Regulatory Risk[2,9,10]

The time required for developers and utilities to conform with regulatory requirements depends upon the extent and ownership of the leasehold area, the size of the project, and the magnitude of the environmental problems encountered. Given the many regulatory reviews required, a major consideration for both developers and utilities is the impact of unanticipated delays resulting in higher development and construction costs.

Environmental issues: Generally, these include problems with liquid or gaseous effluents (H_2S, etc.), with water use and contamination, and with impacts on ecological or social systems in the resource area. Relevant considerations are level of project impacts from geothermal development in the area and the availability of abatement technologies for key emissions.

Institutional issue: Will licensing procedures be streamlined to allow for faster siting of new plants?

- Risk of Public Intervention

Environmental/institutional issues: Of particular concern to developers and utilities are the time and resources required to resolve environmental and land use issues. Governmental policies and programs are still being developed at the federal, state, and local levels, so that developers and utilities bear a risk that nascent policies may change, affecting private investments.

Federal, state, and local agencies have responded to these concerns by providing opportunities for consultation and public comment. Their efforts to streamline the leasing and regulatory processes are discussed in Section 5. A brief description of the regulatory functions of the PUC and the CEC is included in Section 5.22.

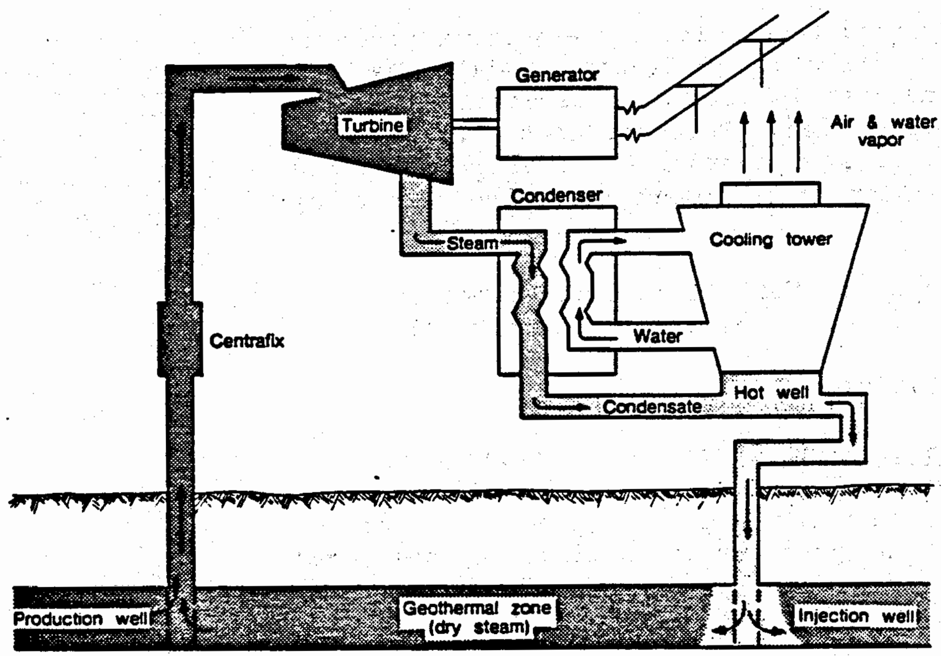
CURRENT TECHNOLOGIES

As new plants are developed and constructed, new technologies will be introduced into the geothermal-electric production process. Several technologies are of interest at present and will be briefly reviewed. Research, development, and demonstration efforts currently sponsored by DOE's Hydrothermal Technology Program are summarized in Section 5.13 below.

Electricity Production Technologies

The method selected to convert geothermal energy to electricity depends on whether the geothermal reservoir is dominated by dry steam or by hot water. In a dry steam reservoir, such as The Geysers, the resource may be used almost directly in the generating turbines. This simple conversion technology involves taking dry steam directly from the ground and expanding it through a steam turbine-generator unit to generate electric power. A graphic representation of a steam generator is shown in Figure 4.21-3.

Figure 4.21-3. Hydrothermal Dry Steam Power Plant

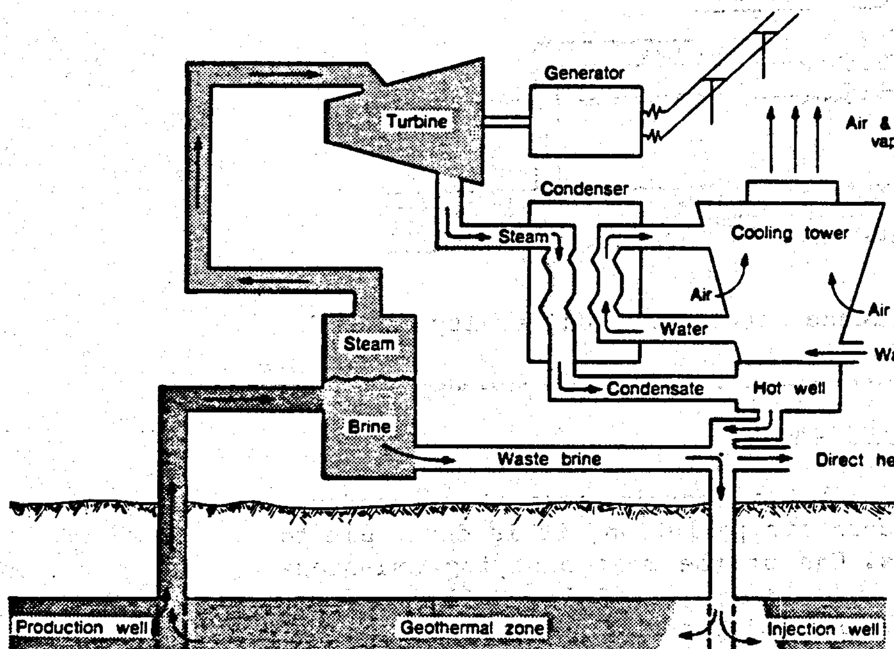


Source: Earth Science Laboratory, University of Utah Research Institute.

A hydrothermal dry steam plant operates at significantly lower wellhead pressures and temperatures than does a conventional plant. As a result, hydrothermal plants operate at lower thermal efficiencies (roughly 15%, compared with 30-40%) and so require steam-production rates two to three times higher than conventional plants of equivalent output. This means that the steam turbines and auxiliary equipment must be sized larger than a conventional design.

Flash systems, binary systems, and combinations of flash and binary are being adapted to produce electricity from liquid-dominated reservoirs in the Imperial Valley. In a flash system, the turbines run on vapor created when geothermal fluids under high pressure and at temperatures greater than 150°C are withdrawn from a reservoir and flashed to steam. The number of flashing stages depends on the temperature and pressure of the resource. In a binary system, the turbines operate on vapor created when the geothermal fluid is used to vaporize a second fluid, such as freon or isobutane, which has a significantly lower boiling point than the geothermal fluid. Figures 4.21-4 and 4.21-5 are schematic representations of these two cycles.

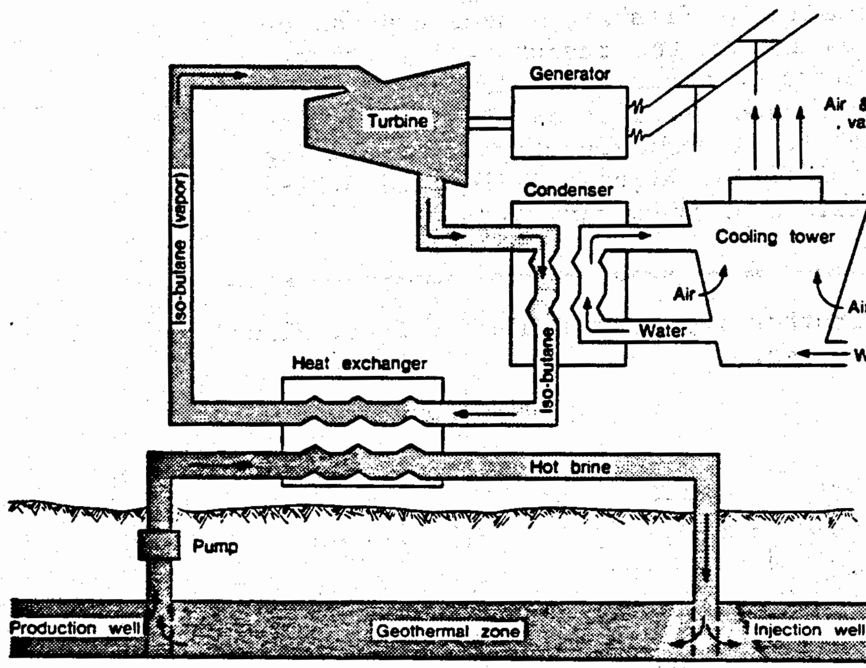
Figure 4.21-4. Hydrothermal, Water Dominated Power Plant Using a Flashed Steam Process.



Source: Earth Science Laboratory, University of Utah Research Institute.

Estimated capital costs for dry steam power plants are between \$450-\$500/KW, \$600-\$950/KW for flash systems, and about \$1,100/KW for binary systems. Total energy costs are between 20-30 mills/KWh for dry steam power plants, and about 50-60 mills/KWh and 65 mills/KWh, respectively, for flash and binary systems coming on line in 1985.

Figure 4.21-5. Binary-Cycle Hydrothermal Power Plant



Source: Earth Science Laboratory, University of Utah Research Institute.

Hydrogen Sulfide Abatement

Because geothermal fluids contain several noncondensable gases which can cause air pollution, it is desirable to control their emissions. One of the most annoying emissions in The Geysers region is hydrogen sulfide (H_2S).* H_2S is released at all stages of the production process, but 90% occurs at the power plant site (which may result in detectable odors similiar to rotting eggs). Various methods have been used to control the level of emissions but no technology has yet been established as the most efficient. Two procedures; chemical treatment, and the Stretford process, have received the most attention.

Chemical treatment uses an iron compound as a catalyst to convert the hydrogen sulfide in the circulating water to elemental sulfur. The system is intended to remove about 90%

*In the Imperial Valley, where the geothermal fields are liquid-dominated, H_2S emissions are confined to the power plant because the geothermal fluid is not discharged to the atmosphere.

of the H_2S.*

The Stretford process uses surface condensers to prevent hydrogen sulfide from coming in contact with the cooling water and dissolving in it. Almost all the H_2S is expected to remain in gaseous form to be conducted to a sulfur recovery unit similar to those used in the petroleum industry.** Units equipped with this kind of abatement are expected to remove approximately 90% of the hydrogen sulfide without the operating problems associated with the iron catalyst system.

Another source of H_2S is steam vented during a power plant shut-down.*** This is a particularly serious problem because it is discharged at a single point, completely bypassing any installed hydrogen sulfide controls. There are two general remedies for this situation: not venting the unused steam, or cleaning the H_2S from the steam before venting. A current practice that allows for some reduction of H_2S is to partially throttle the flow from some wells and reroute some steam to neighboring generating units. Studies are underway on methods to remove the hydrogen sulfide from the steam before it is delivered to the power plant unit. Pre-cleaning the steam would not only control hydrogen sulfide emissions when plants are both operating and shut down, but would eliminate the need to use expensive surface condensers and Stretford units.[11]

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*Geysers Unit No. 11 was designed to use the chemical treatment approach. However, its full evaluation has not yet been completed, and the atmospheric measurements and the frequency of odor complaints suggest that it is not fully effective.

**All units after No. 13 will be equipped with the Stretford process.

***Although the majority of the emissions occur at the power plant, large quantities of H_2S are emitted from the bleed pipes, preventing condensation in idle wells. Wells are idle either before the construction of a power plant or during periods when the power plant is shut down for repairs. Sufficient H_2S escapes from these bleeds to produce detectable odors in the immediate vicinity.

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4.22 SITE-SPECIFIC DEVELOPMENT ISSUES

The pace of development at a given site, and for geothermal energy as a whole, is influenced by the willingness and activities of developers, utilities regulators, planners, and consumers. If their initiatives are blocked by uncertainties, or real or perceived barriers, development will be delayed. These conditions vary at different sites and at different stages in development, so that informational, economic, and regulatory priorities must be tailored to remove critical uncertainties or barriers and to maximize beneficial characteristics.

Individual geothermal areas exhibit unique characteristics which prevent easy comparision. Potential generating capacity and local development issues are different throughout California. Experience at The Geysers dry steam reservoir can only be applied selectively to prospective commercialization of hot water reservoirs because the resource, technological, and economic attributes of hot water resources vary substantially. Regional institutional arrangements among counties and government organizations might be comparable, however.

In this section, The Geysers, Imperial Valley, and selected geothermal areas will be examined in detail. Key issues at these areas are characterized according to technological, economic, environmental, and institutional concerns. Table 4.22-1 shows the clusters of issues by site and when they may become significant barriers to development.

THE GEYSERS

At present, The Geysers is the largest geothermal-electric installation in the world. The 663 MWe generated produces approximately 3% of PG&E's (Pacific Gas and Electric) total electric capacity. Plans submitted by PG&E, Sacramento Utility District (SMUD), Northern California Power Association (NCPA), and Department of Water Resources (DWR) call for rapid development of the resource area. (See Table 2.21-1, above, for a schedule of planned additions by year, developer, and capacity.)

Considerations at The Geysers differ between the steam and hot water portions of the resource. The U.S. Geological Survey has estimated that there is 1,600-3,000 MWe of dry steam potential and approximately 2,000 MWe of hot water potential in this area.[1] The former provides all present power on-line and all projected capacity additions through 1987. Developers and utilities treat the dry steam resource and the technologies for its exploitation as essentially proven.* Second generation issues involving environmental

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* See Sections 2.11, 2.12, 2.13, and 6.1 for a discussion of developer activities at The Geyers.

Table 4.22-1. Geothermal Development Issues at The Geysers, Imperial Valley, and Other Geothermal Areas

		THE GEYSERS	IMPERIAL VALLEY	GLASS MOUNTAIN	SURPRISE VALLEY	MONO/LONG VALLEY	COSO
TECHNOLOGICAL ISSUES	Resource Definition	Mid-term	Short-term			Short-term	Short-term
	Hot Water Technology	Long-term	Short-term				
	H_2S Abatement	Short-term	Mid-term				
	Scaling		Short-term				
	Seismicity		Short-term				
	Subsidence		Mid-term				
ECONOMIC ISSUES	Market			Short-term	Short-term	Short-term	
	Cost of Power		Short-term				
	BLM Lease Re-evaluation	Mid-term	Mid-term				
ENVIRONMENTAL ISSUES	H_2S Abatement	Short-term	Short-term				
	Well-Pad Siting	Short-term					
	Solid Waste Disposal	Long-term	Short-term				
INSTITUTIONAL ISSUES	County Planning	Short-term	Mid-term				
	Transmission Lines	Short-term					
	Cooling/Injection Water		Short-term				
	Federal/State Leasing			Mid-term	Mid-term		

Short-term: Affects current development

Mid-term: Affects full-field development

Long-term: Affects development of new reservoirs in area

Source: See References, Section 4.22.

and socio-economic impacts are now the most salient. In contrast, the hot water resource is in the early stages of development, having been neglected in the past in favor of easier and less expensive dry steam operations. Future development of these resources may be oriented more to direct industrial or agricultural applications rather than to electric power generation.

Two developer/utility teams are participating in geothermal development in The Geysers area.* Both the DWR and the NCPA plan to construct geothermal-electric power plants in the near future. DWR and NCPA can be distinguished from other utilities by the manner in which they are initiating development and by their special financial standing. Both utilities represent public (NCPA) or quasi-public (DWR) interests and hence their economic and risk criteria differ from those of private companies.

The California Department of Water Resources is responsible for constructing and operating the State Water Project. DWR consumes nearly 2% of the state's electricity for pumping water throughout the California irrigation and water supply canals. Presently, the electricity that DWR uses is obtained either by contracts with utilities or by generating power of its own (about 25% is generated by 6 DWR power plants). All DWR contracts for electricity supply expire on March 31, 1983, and thus DWR is under considerable pressure to insure that it has a reliable energy supply after that date.[2]

One of the options that DWR is pursuing is the development of geothermal-electric power. At The Geysers, DWR is in the initial stages (NOI/AFC) of obtaining permits for two 55 MWe power plants. DWR Bottle Rock should be on-line in 1983 and DWR South Geysers should produce power by 1984.

DWR Bottle Rock will be developed by McCulloch/ENTREX and will be funded entirely through DWR to obtain capital at low interest rates (perhaps as low as 6%), which is very attractive for a high capital cost development project.

The Northern California Power Agency represents a group of 12 municipal utilities that have joined together under the Joint Powers Act to form a Municipal Power Agency. Presently, the group purchases electricity wholesale from PG&E and from the Western Area Power Administration. NCPA's present load (peak plus reserve) is approximately 800 MWe. The group is totally dependent upon its suppliers for electricity because it has no generating units of its own. However, by 1985 NCPA plans to have about 500 MWe of its own generating capacity. Two geothermal units and three hydroelectric units will supply about 50% of the required demand in 1985.

The NCPA plans call for the construction of twin 55 MWe units (referred to as NCPA Project #2). Shell Oil will supply the steam. Unit No. 1 should be on-line in late 1981,

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* See Section 3.2 and Section 4.21 for a description of the characteristics of PG&E and SMUD.

and Unit No. 2 should produce power in mid-1982. Development will be financed under the Geothermal Loan Guaranty Program.

Technical Issues

The primary technical issue at The Geysers is the efficiency and reliability of H_2S abatement technologies There has been limited success with new technologies in reducing conversion rates to levels which will allow new power plants to meet regulatory limitations. The status of several H_2S projects are summarized in Table 4.22-2.

Table 4.22-2. Development Division/Geothermal Office Hydrogen Sulfide Abatement Update - The Geysers

YEAR	UNIT	CAP MW	H_2S ppm	H_2S lb/hr	ABATEMENT TECHNIQUES	% ABATEMENT	EMISSIONS lb/hr	COMMENTS
1960	1	11	170	30	None		30	
1963	2	13	170	40	Interim abatement available		40	Abated only when air movement adverse
1967	3	27	450	230	Fe^{+2} catalyst + NaOH + H_2O_2	90 + **	12 **	
1968	4	27	570	290	Fe^{+2} catalyst + NaOH + H_2O_2	90 + **	17 **	
1971	5,6	53/53	280	480	Fe^{+2} catalyst + NaOH + H_2O_2	90 + **	34 **	91% capacity factor before abatement; 76% after
1972	7,8	53/53	200	360	7: EIC $CuSO_4$ scrubber test 8: Interim Fe^{+2} catalyst + NaOH+H_2O_2	test 0-90	180 180-70	7: Test Phase complete. Report on 100,000 lb/hr unit test is due PG&E and DOE in March. 8: Abated when air movement adverse.
1973	9, 10	53/53	110	200	Interim Fe^{+2} catalyst + NaOH + H_2O_2	0-90	200-20	Abated when air movement adverse.
1974	11	106	200	360	Fe^{+2} catalyst + NAOH + H_2O_2	90 + **	25 **	About 50% abatement without NaOH+H_2O_2
3/79	12	106	140	250	Fe^{+2} catalyst + NaOH (+H_2O_2)	85 **	38 **	
?/79	15	55	190*	210	Stretford + Secondary abatement	65	74	Poor H_2S split in surface condensor. Stretford abates H_2S in gas OK. Secondary abatement system due on line in April. Variance expires May 1.
4/80	13	135	90*	230	Stretford + secondary abatement	(90?)	(24)	
8/80	14	110	130*	250	Stretford + secondary abatement	(90?)	(24)	
1981	17	110	350*	700	Stretford + secondary abatement	(97?)	(24)	
1981	16	110	70*	140	Stretford + secondary abatement	(96)	(5)	BACT may apply.
1981	NCPA 2	55	70*	70	Stretford + secondary abatement	(83?)	(12)	
1982	NCPA 2	55	70*	70	Stretford + secondary abatement	(83?)	(12)	
1983	DWR Bottle Rock	55	320*	320	Stretford + secondary abatement	(99?)	(4)	Assuming unproven BACT. Same level of abatement required for vented steam.
1983	18	110	65*	130	Stretford + secondary abatement	(90?)	(24)	
1985	NCPA 1	33/33	300*	360	Stretford + secondary abatement	(99?)	(5)	Assuming unproven BACT.
1984	SMUD 1	55	60*	60	Stretford + secondary abatement	(90?)	(6)	Commitment to 50 gm/GMW

* Estimated

**PG&E was granted a variance by NSCAPCD which limits total H_2S emissions from Units 3, 4, 5, 6, 11, & 12 to 76 Kg/hr.

Field test of Coury steam condensor/reboiler (1,000 lb/hr) was completed. Split of H_2S to noncondensible gas fraction reportedly was over 90%. EPRI will soon receive report.

Source: California Energy Commission, Geothermal Development Updates, March 5, 1980.

Hydrogen Sulfide Abatement Update -- The Geysers

Note that the iron catalyst abatement approach has had the adverse effect of lowering plant capacity factors for Units No. 5 and No. 6. The lower capacity factor greatly increases costs and has a detrimental effect on systemwide baseload capacity. Also, note that in Unit No. 15 the surface condenser has problems because of the Stretford process. Continued government R&D support to test and refine technologies may be needed to avoid delay of proposed development.

Although scale suppression is not as serious a problem at The Geysers as it is in the liquid-dominated reservoirs in Imperial Valley, the prevention of scaling is important to maintainance of operating efficiency.

Other technical considerations are well understood. To produce 110 MWe, PG&E normally requires approximately an 800-acre tract on which 12 to 18 production wells are drilled at an initial density of one well per 40 acres.* Since the steam supplier's plans generally provide for an equal number of initial production and (subsequent) replacement wells, the final field development density is approximately one well for every 20 productive acres.[3]

Technical issues specific to the liquid-dominated portions of the reservoir are not yet clearly defined. They may be similar to those described below in the hot water reservoirs of the Imperial Valley.

Economic/Financial Issues

The economics of electrical power production from dry steam are well developed in The Geysers area. For illustrative purposes, Table 4.22-3 presents comparative generation costs for various fuel types in the PG&E service area.

Note that the generation costs for geothermal are the lowest of all the technologies in the table. The high capacity factor for geothermal (79-80%) and low generation costs make dry steam geothermal ideal for baseload power production. It is hoped that hot water geothermal will share many of these advantages. However, the economics of hot water geothermal production have not yet been clearly defined.

A near term issue of concern to utility companies and developers is the duration of BLM leases. Under current regulations, BLM has the right to adjust the lease terms on federal lands after 10 years of operation.**Thus, at the end

* Thus, PG&E will not enter into steam purchase negotiations unless the developer, or consortium of developers, can offer at least 800 acres.

**Under the Energy Security Act of 1980, the lease term on federal lands has been extended to twenty years. See description of Energy Security Act in Section 7.2 below.

Table 4.22-3. 1985 Comparative Busbar Cost Estimates for Conventional Electricity Generation (¢/Kwh)*

	Geysers Geothermal	Nuclear	Coal	Repowering	Combined Cycle
Capacity Factor	70	60	65	70	70
Fixed Charge**	1.99	4.73	4.02	1.34	1.53
Levelized Operating and Maintenance - Fixed Costs	.13	.09	.17	.20	.12
Levelized Operating and Maintenance - Variable Costs	.03	-	.09	-	.06
Levelized Fuel Costs	3.12	2.74	3.83	7.67	7.67
Total - 1985 Dollars	5.27	7.56	8.11	9.21	9.38

Source: California Energy Commission, Docket No. 77-NOI-4 PG&E Fossil 1 and 2 NOI, 1978.

*Includes generation-related transmission costs; assumes an 11% yearly escalation rate for capital costs.
**What it cost to build the plant.

of this period new fuel contracts would have to be negotiated, and there are no guarantees of the existing lessee's position.[4] Partially because of this, PG&E has refused to plan a power plant on federal land or even to purchase steam from any operators located on federal land;[3] and some large companies are apprehensive that they will be unable to recoup their investment if royalties are increased substantially at the end of the lease period.[5,3] <u>Environmental Issues</u>

The major environmental concern in The Geysers region is H_2S abatement. Another issue is <u>well pad siting</u>. Many of the well sites are located on the sides of the steep ridges common to the area. This unstable terrain is prone to landsliding and must be carefully investigated before final site location.

Adequate final disposal capacity is believed to exist for geothermal wastes from that portion of The Geysers field in current use. There are two regional disposal facilities for solid wastes in Lake County. It is not known if these facilities will be adequate for full development of the KGRA. County solid waste management plans have not addressed the issue completely.[5]

Institutional Issues

The Geysers KGRA covers parts of four counties: Sonoma, Lake, Mendocino, and Napa. Each county has a general plan (as required by state law), but none has a geothermal element in its general plan. The lack of a clear consensus about county growth policies has led to considerable confusion and delay in the development of geothermal resources. These problems are particularly evident in Lake County, which is presently dealing with rapid growth of resort communities as well as utility plans for the construction of six power plants. Citizens in the county are concerned about the potential impact from hydrogen sulfide emissions, increased traffic flow in rural areas, and construction of new transmission lines on the quality of life in the county. Recently, the DWR-Newfield project for a 50 MWe power plant has been abandoned because of the unwillingness of the county to issue necessary permits to the developer on a site adjacent to a housing development.[6] Continued assistance for local and regional planning is needed to facilitate timely resolution of these land use issues.

A near-term problem at The Geysers is the availability of transmission power lines.[7,3,8] Currently, the only lines are owned by PG&E. PG&E has agreed to wheel power from the DRW Bottle Rock No. 1 Project, and it appears that PG&E may also wheel power for the NCPA Project No. 2, although the negotiations are not complete. However, new transmission facilities will be necessary to accomodate PG&E Units No. 16 and No. 17 and the NCPA Project No. 2, Unit 1. The shortage of power line capability is critical because of considerable public opposition to the construction of new power lines in The Geysers area.

The myriad of pre-lease and post-lease regulations regarding environmental documentation have inhibited activities on both the federal and state lands at The Geysers. A recent effort to coordinate data gathering efforts at different federal and state agencies is the Joint Environmental Study (JES) for the NCPA Project No. 2. Under a Memorandum of Understanding, the California Energy Commission will act as lead agency for the preparation of the JES. Three federal agencies involved (BLM, USFS, and DOE) will prepare and process a single environmental document that meets the environmental documentation requirements of each agency.* Sonoma County will be the responsible agency under the CEQA. Since the plant will be located on federal land, the necessary Federal Plans of Operation will be needed. (See discussion in Section 2.21) The necessary Plan of Operations, the JES, and the usual state NOI/AFC process will all take place concurrently.[3]

IMPERIAL VALLEY

Four KGRA's within Imperial County are identified by the USGS as having electric power generation potential; Salton Sea, Heber, Brawley, and East Mesa.** In addition, the Westmorland area, although not a KGRA, is thought to have considerable promise. According to CEC projections, nearly 1,000 MWe may be on-line by 1990. This level of electrical output would represent about 25% of the total estimated potential of Imperial Valley. San Diego Gas and Electric (SDG&E) and the Imperial Irrigation District (IID) are actively developing and constructing goethermal power plants in this region. A project schedule for the Imperial Valley is included in Section 2.21.

Imperial County is the only county in California with a geothermal element in its general plan. Development of public awareness and managerial institutions as a result of this planning process have reduced the amount of controversy associated with geothermal development.[8] The regulatory process attempts to encourage development by separating the various phases of geothermal activity into three separate stages:[9]

1. Exploratory Stage: Developers must obtain a county use permit for all exploratory wells drilled.

2. Testing Stage: Additional use permits are required before developers may drill or use wells in determining the extent and nature of the resources.

3. Production Stage: Separate county approval is also required before a developer may construct a geothermal power plant.

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* This is in support of an Environmental Impact Assessment/Environmental Impact Statement to satisfy NEPA requirements and an Environmental Impact Report to meet CEQA needs.

**Glamis and Dunes KGRAs are not regarded as targets for commercial electric development in the near future.

Technical Issues

A number of technical elements distinguish geothermal-electric development in the Imperial Valley from that of The Geysers. The technologies used for producing power (flash and binary plants) have not yet been demonstrated on a commercial scale in the U.S.* For example, Salton Sea has both higher temperatures and higher levels of dissolved solids than the other KGRAs. Different temperature and salinity levels determine the thermodynamic and economic efficiency of the technology employed to produce electricity. Table 4.22-4 describes the conditions at the Imperial Valley sites.

Table 4.22-4. Geothermal Temperatures and Brine Salinity of the KGRA's in Imperial Valley

Area	Geothermal Resource Temperature (°C)	Total Dissolved Solids (TDS) in PPM
Salton Sea	340	210,000
Brawley	200	100,000
Heber	190	20,000
East Mesa	180	2,100
Dunes/Glamis	135	Unknown

Source: Science Applications Inc., Total Use Scenarios for Imperial Valley Prospects, Review Draft, December 1978.

There are also significant differences within a KGRA, e.g., the brine content of the geothermal reservoir as Salton Sea is much higher in the areas where the KGRA is under water than where it is not.[10] The availability of downhole instrumentation capable of withstanding high temperatures, pressures, and salinities, and technology for corrosion and scale control, is a major industry concern. Pilot plants now under construction at East Mesa, Brawley and Heber will test available technologies under operating conditions.

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* See Section 4.21 for a description of these technologies.

Economic Issues

The economics of geothermal-electric power production are not well developed in Imperial Valley because no full-scale plants have been constructed.* A binary demonstration plant at East Mesa will cost approximately $1,200/kW. SDG&E estimates that its next plant at East Mesa (a 48 MWe unit) will cost about $1,400/kW in 1984 dollars or about 20% cheaper than the 1979 unit after inflation. The 10MWe unit being constructed by SCE at Brawley will cost about $1,700/kW, while the cost for the 10 MWe unit at Salton Sea will be in the range of $1,800/kW. However, SCE projects that the cost for the Heber 45 MWe plant will come down to nearly $1,400/kW.

Environmental Issues

Destruction of geothermal wells during an earthquake is a concern for both developers and utilities. Many geothermal fields in the Valley are located close to or on active faults. The San Andreas Fault could produce a quake of 7 to 7.5 on the Richter scale in this area, while the fault near Brawley is believed capable of 6 to 7. Earthquakes can extinguish geothermal production in some areas and enhance it in others. This unpredictability adds to the investment risk associated with geothermal resources. Further efforts at reservoir modeling may increase knowledge of seismic behavior and improve siting practices.

Hydrogen sulfide abatement in the Imperial Valley is not thought to pose as serious a problem as in The Geysers area, even though H_2S concentrations may be equivalent in some areas. The primary reason for this is that the binary cycle does not discharge geothermal fluids to the atmosphere. The gas is entrained in the geothermal fluid, which is injected back into the ground after the beneficial heat has been removed. Some of the gases may come out of solution, but their release may be mitigated by the use of tall stacks or mixing with air from the cooling tower. However, at sites where a flash cycle is employed and in areas with high concentrations of hydrogen sulfide, abatement procedures similar to those in The Geysers may be used.

No regional geothermal waste facility exists in the Imperial Valley at present, although Imperial County and private industry have proposed a number of sites. Geothermal wastes are currently hauled to the Los Angeles area (the nearest suitable site), or stored temporarily in drilling field sumps, or occasionally disposed of in local

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*Developer and utility interests in the Imperial Valley are further discussed in Section 6.1 below.

(inadequate) facilities. Some liquid wastes are programmed for injection. The Imperial County Solid Waste Management Plan does not adequately address the issue and must be updated to allow the facility permits to be approved.[5]

Institutional Issues

Geothermal development will affect the allocation of water in the Valley in two ways. First, the power plants will require considerable make-up water for water lost through evaporation in the cooling cycle.* Second, there is a possibility that subsidence will accompany the removal of geothermal fluids. Should it prove to be a factor, injection of fluid back into the reservoir rock would be required to prevent subsidence.

The possibilities for obtaining external water include: Colorado River water from the All-American Canal, groundwater, Salton Sea water, the New River, geothermal brines, and agricultural drain water.[11,13] None of these sources are desirable. Colorado River water is used almost exclusively for agriculture; groundwater is scarce. Salton Sea water is highly saturated with brines which would cause corrosion and scaling problems. Finally, agricultural drain water is needed to help keep the salinity of the Salton Sea below levels which would both destroy the sport fishing industry and threaten the Salton Sea National Wildlife Refuge. Although SDG&E believes agricultural drain water to be the most attractive source, it is also actively considering the New River as a potential source for injection water.**

As in The Geysers, the availability of transmission line capacity is a severe problem for geothermal development. The Arizona Public Service Company (APSC) and San Diego Gas and Electric (SDG&E) signed an agreement (November 1978) to construct a 500 KV transmission line between the Palo Verdes nuclear plant and a SDG&E substation in San Diego, running through the Imperial Valley. However, APSC has suspended indefinitely its plans to construct Palo Verdes Units 4 and 5 and the status of the power line is uncertain.[12]***

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*It is estimated that a binary plant using geothermal fluid at 150°C will use 70% more cooling water than a flash system. As the geothermal fluid temperature increases, the difference between the two technologies decreases.

**See Section 7.2 below for an update on the availability of cooling water.

***See update of development activities in Section 7.2.

COSO

Coso is the other area in which electricity production is planned for the near future. The geothermal reservoir underlies approximately 100,000 acres of federal land in Inyo County. Most of the land is managed by the Naval Weapons Testing Center (NWTC) at China Lake; the rest is land administered by the Bureau of Land Management (BLM). Both agencies are now planning for development and are working with state and local agencies to coordinate environmental review, leasing, and development activities.[13]

The type of geothermal energy at the Coso area is not known at this time. Indirect studies show that it may be a vapor-dominated system similar to The Geysers, but drilling to date by the Department of Energy has been unsuccessful.

The Navy plans development for on-site use at the NWTC.* Design work and permitting are now underway. Ultimate production on Navy lands has been estimated to be as high as 300 MWe.[19]

The BLM is now developing a leasing program for the land it administers. Leasing of some Navy land for commercial development is also under consideration.

WENDEL-AMEDEE, SURPRISE VALLEY, LASSEN VALLEY, and GLASS MOUNTAIN KGRAs

Large-scale development at these KGRAs in northern and northeastern California is inhibited by small local energy demand and long distances from load centers. The estimated electrical potential from Mono-Long Valley, Wendel-Amadee, Surprise Valley, Lassen Valley, and Glass Mountain is 3990 MWe for 30 years.[1] Instead, small projects meeting local electricity and direct heat requirements are being pursued. Development at these isolated areas may follow that occurring at Wendell-Amadee KGRA (Lassen County) where a geothermal green house project is expanding, and a 50 MWe cogeneration (geothermal/wood-chip) plant is under consideration.

In the Surprise Valley KGRA (Modoc County), direct heat applications are considered feasible, but have not been investigated beyond a preliminary market survey of Modoc and Lassen Counties funded by CEC.**

No development activities are underway at Glass

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*See Section 2.2.

**See update of activities in Section 7.2

Mountain KGRA (Siskiyou County). Applications to lease federal lands have been received by the Klamath Falls Forest Service, but no leasing of Forest Service lands will occur until the completion of a RARE II study.

MONO-LONG VALLEY

In the Mono-Long Valley KGRA, commercialization activities are presently concentrated around Mammoth Lakes Village. The CEC and DOE have co-funded a space heating and snowmelting study and demonstration, and are now financing a resource and market survey. Southern California Edison and others are considering construction of a 32 MWe co-generation plant in the area.

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4.3 DIRECT GEOTHERMAL APPLICATIONS

4.31 GEOTHERMAL SHARE OF THE THERMAL ENERGY MARKET

The current use of geothermal resources in California comprises a very small portion of the market for thermal applications. Existing (1979) direct applications for spas, hydroponic greenhouses, aquaculture, and space heating is equal to less than .02% of 1975 thermal energy consumption in the state.* Table 4.3-1 presents the Department of Energy's estimate of existing and planned thermal applications in California and the Western U.S.

Table 4.3-1. Existing and Planned Geothermal Energy Use as a Thermal Energy Source (10^9 Btu/Yr.)

	1979	1982	1985
Hawaii	1.5	4.0	50
Washington	11.95	15	50
Oregon			
Klamath Falls	553.15	852.15	1495
Ontario (ORIDA) (possibly start district system by 1985)	0	355	
Timberline	-	60	60
Others	66	100	150
California			
Calistoga) Paso Robles) Wendell Amadee) Desert Hot Springs) Mammoth) Bishop)	224	300	400
Susanville	small	41	111
Holly Sugar		1300	2110

Source: Department of Energy, San Francisco Operations Office, August 1979.

A significant market constraint for direct geothermal applications is the requirement that the end-user and the resource be located together. The temperature, flow rate,

*A description of current projects in California is included in Section 2.22, including those in the engineering and economic assessment stage.

salinity, and potential emissions and effluents are the principle factors which determine a resource's economic usefulness. While improved pipeline transportation is under investigation, the high costs associated with resource transmission and heat loss reduction severely diminish feasibility as distances increase.*

The interest in direct geothermal applications is increasing in California. DOE has co-sponsored with the California Energy Commission a preliminary evaluation of thermal applications suitable for identified geothermal resources, including; hospitals, colleges, hotels, food processing, pulp and paper, chemicals, petroleum refining, and rubber and plastics manufacturing.[4] Results from more specific market potential studies by Science Applications, Inc., and Research Planning Associates are currently being evaluated. These reports should better delineate the potential market by counties and help formulate appropriate commercialization initiatives.

PATTERNS OF DIRECT APPLICATIONS DEVELOPMENT

Patterns of entry into the direct-use market have shifted over time. Three overlapping kinds of development have occurred; they may be characterized as location determined, economically viable, and government-aided ventures.

Location-based operations are those that emerged from the early co-location of an easily accessible resource and a conventional application. Virtually all commercial resorts were initiated in this fashion, as were all space heating and process heating applications in the state. The heating systems at Susanville were started in this manner, as the town sits atop an easily accessible, low-temperature (36°C - 39°C) reservoir. Similarly, geothermal heated greenhouses in Wendel-Amedee use an open hot spring as their heat source. At the present stage of geothermal development, these applications can contribute significantly to resource assessment efforts and industry know-how, while increasing public confidence in the environmental acceptability of geothermal development. However, the potential contribution of this

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* In any direct application of geothermal resources, the required proximity of the resource to the user will depend on the specific characteristics and the particular end use involved. The Geocity model developed by C. Bloomster at Pacific Northwest Laboratories has shown certain low-temperature district heating applications to be technologically feasible with transmission of up to 50 miles.[1] See also recent DOE study by John Beebee which concluded that a million Btus can usually be transported economically for less than $1.00 if the load factor exceeds 500×10^6 Btu/hr.

type of development to thermal power on-line is limited, compared to most industrial process heat applications.

Increasingly, the engineering and economic feasibility of potential geothermal ventures are formally analyzed prior to making an investment commitment. Such an approach was employed by Calaqua and Geoproducts in their initial hydrothermal ventures. Both these companies investigated various opportunities before electing to proceed with their investments in fish farming and hydroponic greenhouses. In each case the decision to utilize geothermal resources rested upon the price competitiveness of the fuel source for the application, and the availability of a suitable site. This analytical approach is vital to consideration of new energy resources and will probably be the standard for future direct geothermal applications. For example, in both firms referred to above, the suitability of their particular processes to certain geothermal attributes (such as a temperature, cost, constant supply) was a significant decision factor. (See Section 4.32 for a more detailed discussion of considerations affecting investment in direct use applications.)

The third mode of entry covers those applications aided by government programs. Government involvement, which has increased at all levels as a result of The Geothermal Steam Act and subsequent legislation, can help to relieve economic and institutional uncertainties associated with first-of-a-kind hydrothermal applications. These actions will assist the potential user in dealing with the complexity and variety of geothermal applications.

Direct applications at Mammoth, Desert Hot Springs, and Mecca have received financial assistance from either DOE, CEC, or both. In particular, the Mammoth and Susanville projects highlight the growing role of state and municipal governments in the development of geothermal applications.

At Mammoth, CEC sponsored a pilot geothermal heating system and a snow melting demonstration, following a feasibility study sponsored by DOE. Susanville is a small community in northern California which hopes to broaden its economic base by developing hydrothermal resources for a district heating system and a commercial park. The participation of local governments becomes increasingly important in the present generation of projects with more complex applications, such as district heating or multiple-use projects. For first-on-site applications, the wide array of institutional and regulatory issues encountered are often most effectively managed by municipalities interested in economic development and securing a relatively inexpensive source of energy for district home and water heating.

4.32 MARKET CONSIDERATIONS

While the cost of power from geothermal energy is competitive with alternative sources for many thermal applications, the co-location requirement of direct use necessitates the consideration of a number of unique factors besides energy cost. Consideration of the other costs associated with co-location, and whether they are offset by the savings in energy cost, may be the key to the expansion of the direct-use market in California.

The potential market for direct use may be divided into four categories: (1) retrofits, (2) new plants (for existing businesses needing additional capacity), (3) new geothermal applications generated by growing markets for particular end products, and (4) relocations of existing facilities.

Before selection of a geothermal application, a business must consider the economic impact from that choice of energy supply. That is, will the added revenues and increase in savings outweigh the additional costs and risks of the project. Because energy is an input to production, the benefit of a decrease in energy cost must be weighed against the increase in other costs necessary to achieve those decreases, such as transportation of raw materials to remote sites. The more energy-intensive a product is, the larger the potential savings available, and the greater incentive for consideration of energy alternatives. Table 4.3-2 summarizes input cost estimates for a number of direct-use applications.

Transportation and marketing are two variables that will have an important influence on these costs. Presently, identified geothermal resources exist predominantly in remote regions of the state, which makes transportation a significant cost. The importance of this factor will depend on the product involved, the amount of raw materials used, and the distances to both supply and end markets which determine the costs of appropriate transportation.

The total fixed costs of the system must be spread across the units of usage to provide a unit cost, or energy cost.

$$\frac{\text{TOTAL FIXED COST}}{\text{ACTIVITY LEVEL}} = \text{UNIT COST}$$

As the load factor goes up, the unit cost will be reduced. The DOE funded study by Gruy Federal concluded that the level of utilization was the most important single factor in actual end-use cost. In 85% of the cases, actual cost

Table 4.3-2. Equipment and Material Cost Estimates for Typical Direct Use Applications (1978 Price Level - $/Million Btu/Yr.)

Application	Geothermal <80°C	Resource 80-115°C	Temperature >115°C	Capacity Factor
Hospital	11.70	8.30	6.90	60%
University/College	17.30	11.70	8.90	35%
Hotel*	60.00	40.00	31.00	25%
Food Processing	-	1.70	0.86	90%
Lumber	-	2.86	1.70	90%
Pulp and Paper	-	-	0.70	90%
Chemicals	-	2.30	1.20	90%
Petroleum Refining	-	-	1.00	90%
Rubber and Plastics	-	-	2.00	90%

Source: Rigby, Larson, Racine, Gratt, and Irving, An Overview of Prospects and Potential for Development of Geothermal Energy for Direct Use in California, Science Applications, Inc., August 1978.

*Estimates include costs of well pumps and pipelines; for hotels this has a major impact on unit costs (which would be mitigated if several hotels or other buildings were to be served).

exceeds that at optimal utilization by a factor of two or more. Similarly, many other factors, varying in type and importance with each application and resource area, must be considered. A sample of relevant factors affecting greenhousing, kiln drying lumber, feed lots, onion dehydration, geothermal, and aquaculture applications in Lassen and Modoc Counties is presented in Table 4.3-3.

A major economic constraint facing geothermal development is its high front-end cost.* As opposed to purchasing

*The study by Gruy Federal for DOE showed that the portion of geothermal energy cost attributable to wells, downhole pumps, injection pumps, and auxillary equipment exceeded 50% in 14 of 20 engineering and economic studies evaluated. The capital intensity of direct application is further underscored in that these estimates do not include transmission systems and heat extraction units which also require initial investment capital.

Table 4.3-3. Summary of Influence Factor Effects on Geothermal Energy Applications

Influence Factor	Greenhousing	Kiln Drying Lumber	Feed Lots	Onion Dehydration	Aquaculture
Climate	Major factor in use of energy.	Negligible factor	Major factor in use of energy.	Negligible factor	Major factor in use of energy.
Fresh Water Requirements	Less than 1/10 of field grown crops.	Negligible factor	Negligible factor	Negligible factor	Requires about one well per acre of pond in cold weather.
Shipping	Truck or railway south to Reno. Energy savings exceed trucking costs.	Existing industry. Established shipping costs not affected.	Added production compensates for additional cost of shipping feed.	Dehydrator reduces weight by a factor of 6 – 7 and saves shipping costs.	A negligible factor. Shipping cost less than 1% of market price. Negligible factor.
Marketing	Existing; markets during off-season of field grown product. Higher market price, better quality.	Existing industry, not a factor.	Coop feed lot could put profit from this element of marketing into pockets of hard pressed ranchers.	Would not alter product quality. Could influence new industry in area.	Current market price cannot cover cost of geothermal energy, but long-term potential is good.
Labor	Most labor effective of applications. A 10 acre facility would need 30 – 50 personnel.	No direct change in labor requirements between old & geothermal method of drying.	18,000 head per year production requires 10 – 15 persons.	800 - 1000 acres of onion land plus dehydrator plant would require several hundred persons.	Labor is 30 to 40% of grow-out cost.
Terrain	Can be installed on hillsides but no lack of flat land in area.	Flat terrain preferred	Flat terrain preferred	Flat terrain preferred	Flat or gently sloping terrain preferred.
Environmental Considerations	No change to existing systems except reinjection of geothermal water.	No change to existing systems except reinjection of geothermal water.	No change to existing systems except reinjection of geothermal water.	Some odor from drying operations. Locate away and down wind of inhabited area.	Reinjection of geothermal water. Fresh water overflow is clean enough to support fish.
Research	Not required	Not required	Optimized spacing and sizing of underground pipe in particular soils.	Not required	Testing to determine if aquatic animals can be grown directly in particular samples of geothermal water.
Quality of Geothermal Field	All systems involve closed pipes. Only potential problem is corrosion and scaling. General high pH of geothermal waters in Lassen and Modoc Counties will prevent corrosion. Low solids will minimize scaling.				
Multi-use	Can be located downstream of kiln drying.	Discharges high temperature water suitable for further use by greenhouse feed lot or aquaculture but economic advantage is small.	Can be located downstream of kiln drying.	Marginal	Current profits too low to pay for required heat exchange, but long-term potential excellent.
Quality of Product	Not affected by geothermal energy.	Not affected by geothermal energy.	Cattle gain more weight in heated feed lot when outdoor temperatures are low.	Not affected by geothermal heat.	Heating allows maintenance of ideal temperature — higher yields.
Temperature Enhancements (process requirement)	Not a factor	Required for some species of wood.	Not a factor	Water must be heated from 212°F (study limit) to 240°F for 1st stage drying.	Not a factor
Peaking Temperature (weather requirement)	Extended periods of extreme cold could require peaking.	Not a factor	Not a factor	Not a factor	Extended periods of extreme cold could require peaking.
Uninterruptable Supply	Loss of heat source could result in catastrophic crop loss.	Temporary delay in production.	Loss in production efficiency.	Temporary delay in production.	Loss of heat source could result in catastrophic crop loss.

Source: Economic study of Low Temperature Geothermal Energy in Lassen and Modoc Counties, California, VTN - CSL, April 1977.

conventional fuels (oil, gas, coal, electricity), larger capital costs must be incurred at the outset. A very large portion of total costs involved is for either resource development (i.e., feasibility studies, drilling costs, interest associated with regulatory delays, etc.) or for the construction of the initial utilization system. Many of these costs cannot be calculated with precision before incurrence, nor can system utilization or the load factor be estimated accurately. The economic burden of acquiring the additional capital necessary before production begins can be an onerous one, particularly for smaller businesses. It entails additional risk in that any delays in reaching anticipated operating levels will rapidly increase interest costs as well as delay revenues from operation.

To summarize, the primary considerations which an enterprise must resolve before choosing a geothermal application (as compared with more conventional fuel sources) are: resources reliability, financing, and technical expertise in geothermal engineering. The analytical approach of designing a venture and its economic workings around a known technology, and then locating a suitable geothermal resource will facilitate these kinds of deliberations.

POTENTIAL MARKET FOR DIRECT APPLICATIONS IN COUNTIES WITH IDENTIFIED RESOURCES

The following is a short summary of the outlook for direct geothermal applications in counties with identified resources. Near-term potential markets are located in areas near population centers and transportation facilities and where development for electric power production is underway. A major issue for future development is utilization of the large resource base located in remote, mountainous, and desert areas. Ongoing DOE and CEC market studies should better identify resource and user matches in California.*

o The Geysers

Lake and Mendocino Counties - Direct-use potential is good, especially for the wood products and agricultural industries. District or individual home space heating is possible in a few locations, but the major towns (Ukiah, Cloverdale, Lakeport) are not located near a resource. The transportation network in Lake County is presently limited by the hilly terrain, but the presence of geothermal wells drilled for electric power development could encourage direct uses. Along the

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* Also see recent map of low and moderation temperature resouces compiled by the Divison of Mines and Geology, entitled "Geothermal Resources of California", 1980.

shores of Clear Lake, development restrictions have been posed by numerous resort owners and residents. At Middletown, a private school is planning to use steam from a nearby exploratory well for its heating and cooling needs. On the west side of Clear Lake, a resort has a swimming pool heated by a low-temperature geothermal well. Mendocino County has better transportation access because of highway 101. Another geothermal area west of Boonville and Ukiah has shown some prospect for low-temperature development.

Napa County - Geothermal resources are located in the northern Napa Valley, a premium wine region. Space heating and other uses are feasible there (pop. 50,000), but are not likely in the populous southern end of the county (Napa city). Geothermal space heating is being considered for a city firehouse in Calistoga. The strong slow/no growth attitude of the county residents presently dictates slow geothermal development. Agriculture preservation in the Napa Valley (Calistoga) is a prime concern.

Sonoma County - Development of direct-use potential in The Geysers region of Sonoma County faces major development problems due to transportation and terrain difficulties. The Sonoma State Hospital is considering use of the geothermal heat for space conditioning and hot-water heating and other space conditioning applications may be feasible in the Valley of the Moon. Eventual development in the Skaggs Hot Springs area for residential, commercial, and industrial development may be limited.

- Imperial Valley

Imperial County - Probably has the best direct-use potential of any county in the U.S., due to the extensive nature of the high temperature geothermal resource; large number of energy intensive agribusinesses; widespread industrial facilities; numerous sites for new industry; excellent transportation network; and proximity to major industrial and agricultural markets. Salinity of geothermal fluids and water availability are the major constraints. DOE is partially funding aprotect to cool, heat, and provide domestic hot water to the community center at El Centro. The project is the first phase of a proposed distrinct cooling and heating program for the City.

San Bernadino and Riverside Counties - The population is heavily concentrated in the western areas. Most of the geothermal resources are located in the eastern areas. Increasing energy costs, population expansion, and possible improvements in geothermal technology (e.g., transportation of the heat from the source to the user) should encourage development. The primary use of geothermal waters are for spas and some space heating and cooling. The resource at Desert Hot Springs has been evaluated for possible use in district space cooling, acquaculture, and greenhousing. At Mecca, a geothermal aquaculture business is planning to expand its operation to raise giant Malysian prawns.

o Other Geothermal Areas

Lassen and Plumas Counties - Susanville is currently constructing a district heating system and plans to establish a geothermal industrial park. Several geothermal greenhouses and a refrigeration system are in operation at Wendel-Amedee. The California Department of Water Resources and a private corporation are studying the feasibility of a power plant that would use geothermal waters and wood waste to generate 55 MW of electricity for use in the State Water Project.

Shasta and Siskiyou Counties - The location of Big Bend Hot Springs is not conducive to industrial development. It might, however, be an acceptable location for a wood products industry.

Modoc County - Due to he areas isolation and small population, direct heat applications will probably be first use in agriculture. The Fort Bidwell Indian Reservation in Surprise Valley is contemplating use of geothermal fluids for space heating, agriculture, and greenhouse operations. DOE is partially funding a project at Kelly Hot Spring that will use geothermal fluids to supply heat to a feedlot operation.

Mono County - District heating is possible at the town of Bridgeport (pop. 500) which is located about a mile from Travertine Hot Springs. The California Depoartment of Transportation has investigated the possibility of using geothermal heat in a proposed highway maintenance station near town. Commercial/electric development possibilities exist in the Long Valley Caldera. Recently, the use of geothermal heat for space heating and snow melting was successfully demonstrated at Mammoth. A district heating project is now under consideration. Near Casa Diablo, the largest rainbow trout hatchery in California uses geothermal waters in its operations.

Sierra County - Cattle ranching is the major business in Sierra Valley (Beckwourth Peak area). Possible geothermal applications include agricultural processing and district heating of small communities. The City of Santa Clara has purchased land in the valley with the intention of using the land§s geothermal resources for (1) conversion of wood chips to methanol, (2) space heating , and (3) generation of electricity using geothermal waters aand combustion of forest product wastes.

Inyo County - Several remote areas have good geothermal potential (Coso, Tecopa, and Trona Hot Springs). The large chemical industry at Trona has shown interest in using geothermal heat in some of its industry processes. Development of Coso Hot Springs, on U.S.Navy lands, may provide a model for surrounding areas.

Kern County - Geothermal resources are located in the desert areas near Inyo County.

Santa Barbara, Ventura, San Luis Obispo, and Monterey Counties - The geothermal resources are generally of low temperature and are distant from the population centers. Near the town of Paso Robles, geothermal waters are being used at a catfish farm and for irrigation. The pristine condition of the area and abundant wildlife around Sespe Hot Springs makes environmental issues a major concern in geothermal development.

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RESOURCE PROFILE
DEVELOPMENT ACTIVITIES
ENERGY SUPPLY and DEMAND
GEOTHERMAL ENERGY MARKET

5. GOVERNMENT ACTIVITIES and INITIATIVES

PRIVATE SECTOR ACTIVITIES
SIGNIFICANT EVENTS

Section 5. GOVERNMENT-SUPPORTED ACTIVITIES AND INITIATIVES

The roles and policy instruments available to each level of government are unique and are interrelated aspects of the environment for geothermal energy commercialization. Historically, the federal effort has focused on the initial phases of geothermal development: resources assessment, technology development, economic incentives, and streamlining of federal leasing and permitting procedures. More recently, a greater emphasis has been given to accelerating the pace of private sector investments in hydrothermal resources.

State energy programs have been involved primarily with the regulatory aspects of geothermal development. In California, as geothermal energy emerges as an "environmentally preferred energy source," significant efforts are made by regulatory agencies to rationalize the regulatory framework as a means to expedite development. Another important state initiative is the enhancement of local administrative capabilities to manage resource development. A two-fold transfer of expertise and authority is taking place from the state to county governments. State agencies are providing information and expertise to local administrators to enable them to understand and plan for the impact of geothermal development. Recent legislation has also provided for transfer of authority over siting and operation of geothermal facilities.

County and municipal governments at key resource areas are reviewing the costs and benefits associated with geothermal projects and the distribution of potential impacts on the community's residents. They are analyzing the actual trade-offs (land use, socio-economic impacts) between the community's quality of life and geothermal development.

This section describes the federal, state, and local activities related to geothermal development in California. The goals and objectives, strategy, and management approach of federal hydrothermal commercialization programs are presented in Section 5.1. Individual DOE programs are summarized in Sections 5.11-5.14. Section 5.2 describes the development of existing state and local programs.

5.1 THE FEDERAL HYDROTHERMAL COMMERCIALIZATION PROGRAM

INTRODUCTION

"Commercialization" is the process by which different organizations seek to expand the private sector applications of a particular technology. Traditional instruments available to public agencies have included support of basic research and development, demonstration of prototype and pilot projects, economic incentives, and dissemination of information to the public. The choices of particular technologies for government support are often in response to perceived public need, supported by preliminary assessments that evaluate relevant technical, economic, environmental, and institutional issues.

In this context, the role of the Department of Energy (DOE) in geothermal development has changed during the past few years. As particular R&D programs mature, supported by an intensive resources assessment effort, DOE has evolved from a sponsor of pure research into the arbiter or remover of particular market barriers. The goal of the present program is to maximize utilization of the nation's geothermal resources in an environmentally and socially acceptable manner, and to establish the resource as a significant contributor to national energy needs (as a replacement for imported fuels).*

The following section summarizes information about the hydrothermal commercialization program contained in the Third Annual Report of the Interagency Geothermal Coordinating Council, DOE's FY 80 Program Summary Document for Geothermal Energy[1] and the FY 80 Multiyear Program Plan for Geothermal Hydrothermal Resources[2]. A number of changes have occurred at DOE since this text was completed in December 1979. As part of an overall DOE reorganization, a new Division of Geothermal Energy that combines the R/D/D functions of the Division of Geothermal Energy and the commercialization responsibilities of the Geothermal Resource Manager was created in late 1979 under the Assistant Secretary for Resources Applications. The Director of the new

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* The geothermal/hydrothermal resource development and commercialization program was authorized through several statutes involving multiple agency responsibility and dispersed authority. The Geothermal Steam Act of 1970 (PL 91-581) authorized the Secretary of the Interior to lease and regulate the use of geothermal steam and associated geothermal resources on federal lands. Subsequent reorganization acts (PL 93-438, PL 93-577, PL 95-91) established an Interagency Geothermal Coordinating Council (IGCC) and named the DOE as lead agency for coordinating the federal geothermal energy program.

Geothermal Energy Division is now responsible for the management of the federal program as successor to the functions of the former Geothermal Resource Manager. Updates of recent program activities are contained in Section 7.3.

Geothermal Commercialization: Program Goals and Objectives

The overall DOE program goal is to increase commercial use of geothermal energy from the present 0.04 quads/year up to the Intergovernmental Geothermal Coordinating Council (IGCC) goals for hydrothermal-electric and direct-heat applications.[3] (See Table 5.1-1)

Table 5.1-1. IGCC Goals for Hydrothermal Utilization (quads/year)

	1985	2000
Electric	0.2-0.3	1.5-3.0
Direct Use	0.1-0.2	0.5-2.0
Total	0.3-0.5	2.0-5.0

Source: Department of Energy, Division of Hydrothermal Resources Management, Fiscal Year 1980 Multi-Year Program Plan for Geothermal Hydrothermal Resources, October 1979.

A further objective is to make a significant contribution to the President's plan to reduce oil imports.[2] Achievement of the 1985 goals would replace the 36.5 - 55 million barrels of oil per year that would otherwise be required to produce 3,000-4,000 MWe, and the equivalent of 18 - 36 million barrels of oil per year in direct heat applications. The program goal for 1990 is to provide from 0.2 - 0.6 quads of direct heat from low-to-moderate temperature geothermal resources, replacing 36 - 100 million barrels of oil per year (3-9% of projected oil use for space and hot water heating).[2]

PROGRAM STRATEGY

Electric Power Development

The DOE strategy for hydrothermal electric power generation is to expand existing dry steam resource development to the much more extensive liquid-dominated systems. The specific strategy is to accelerate the pace of development by:[3]

- Stimulating industry to explore for and establish reserves.

- Reducing technological and environmental risks.

- Providing temporary economic and financial incentives to offset deterrent effects of new technology risks and reservoir uncertainties.

- Increasing public awareness and active consideration of geothermal potential.

Direct Thermal Applications

Although electric development activities will continue during FY 80, increasing emphasis will be placed on developing the very large, but essentially unexploited low-to-moderate temperature hydrothermal resource for direct heat applications. Present direct use of geothermal heat in the United States corresponds to only about 0.01 quads (compared to 1985 goals of 0.1-0.2 quads).*

The commercialization strategy followed by DOE combines resources assessment efforts (under the leadership of the USGS) with information dissemination and financial and technical assistance to potential users. A three phase cost-shared development program provides for: technical/economic analyses of applications at specific sites; reservoir confirmation drilling;** and support for project construction through the Geothermal Loan Guaranty Program.

This program will focus on the larger users, such as municipal district heat systems, industrial space and process heat users, and large agricultural drying operations.

MANAGEMENT APPROACH

The basic management approach for the hydrothermal commercialization program is the informed participation of all DOE entities and other federal agencies responsible for hydrothermal development, with the oversight of the IGCC and the Division of Geothermal Resources Management (now Division of Geothermal Energy). Management matrices are established at three principal levels; federal, DOE Headquarters, and DOE Field Offices.

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* See also Table 4.3-1, Existing and Planned Geothermal Energy Use as a Thermal Energy Source.

**See announcements of the User-Coupled Drilling Program for Direct-Use Applications.

•Federal

Leadership and coordination of the federal hydrothermal development program is provided by the Interagency Geothermal Coordinating Council (IGCC) and its sub-units. The responsibility of the Council, in accordance with the provisions and intent of PL 93-410, is to

> ...coordinate those Federal plans, activities and policies which are related to or impact on geothermal energy.... [and to] make recommendations to the appropriate agencies and the President with regard to alternative policies or actions considered necessary or desirable to expedite the development utilization of geothermal energy resources.

Figure 5.1-1 shows the organizational structure and membership of the IGCC.* The responsibilities of various federal agencies in geothermal development are depicted in Figure 5.1-2. Federal funding for geothermal energy programs is presented in Table 5.1-2.

The Chairman of the IGCC, who has statutory responsibility for the total federal program, is the DOE Assistant Secretary for Resources Applications; the Chairman of the Staff Committee is the Director, Division of Geothermal Energy. The Staff Committee is responsible for formulating federal geothermal program plans and for directing the activities of the Budget and Planning Work Group, the Resources Panel, the Research and Technology Panel, and the Institutional Barriers Panel. The six agency members of the Staff Committee are appointed by the Council and represent sub-organizations of those federal agencies on the Council itself.

•DOE Program Organization

Within DOE, geothermal commercialization activities are supported by a number of divisions. Lead responsibility for planning and outreach activities is carried out by the Division of Hydrothermal Resource Management (now Division of Geothermal Energy) under the Office of the Assistant Secretary for Resources Applications. The Geothermal Loan Guaranty Program, coupled with existing tax incentives under the National Energy Act,** is the main source of financial incentives. Hydrothermal technology developments conducted

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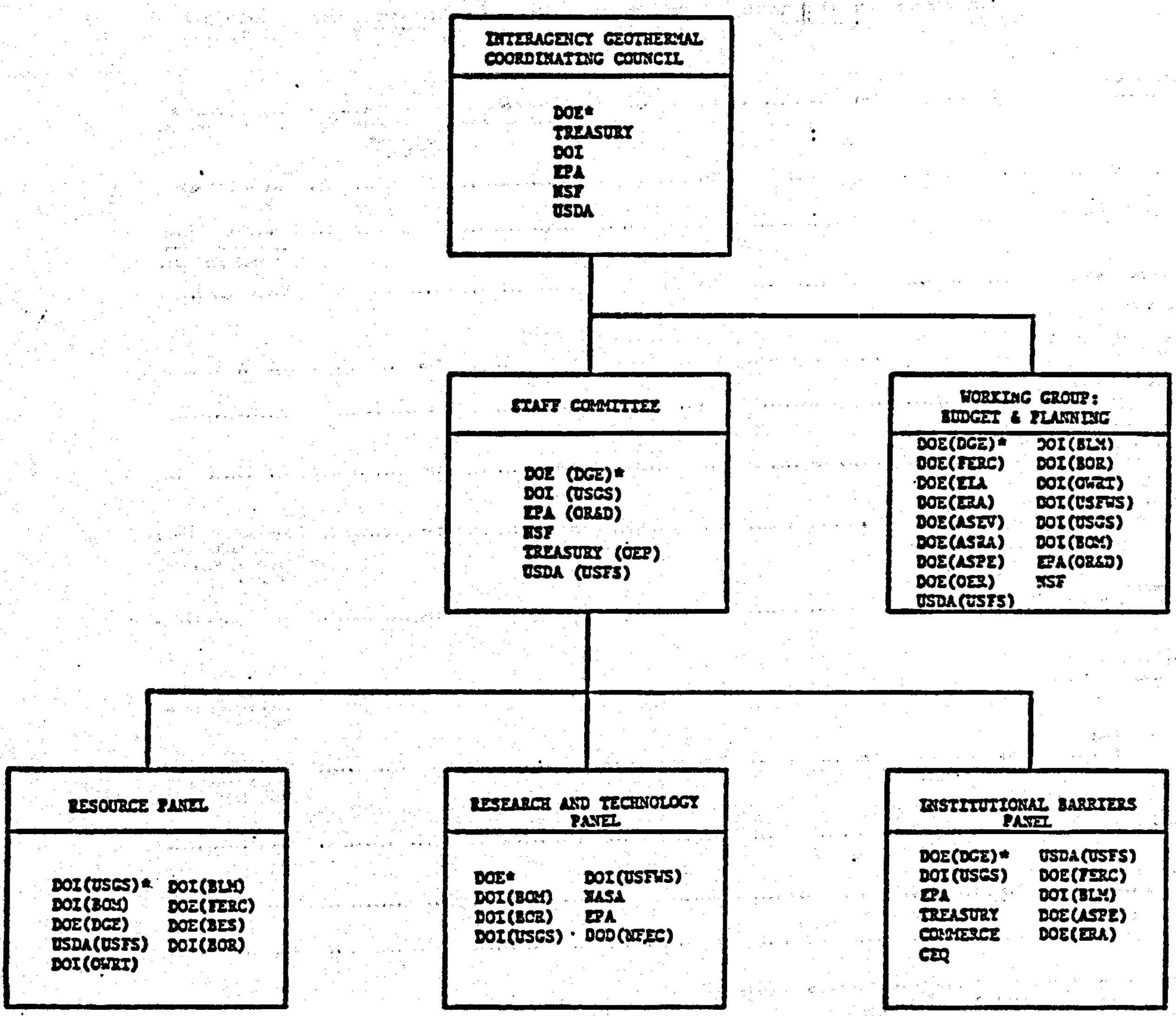
*See update on IGCC membership, Section 7.3.

**See Appendix 1 for a discussion of incentives available under the NEA. See Section 7.3 for a description of new incentives available under the Energy Security Act of 1980.

FIGURE 5.1-1. IGCC Organizational Structure.



LEGEND

ASEV-Office of Assistant Secretary, Environment
ASPE-Office of Assistant Secretary, Policy and Evaluation
ASRA-Office of Assistant Secretary, Resource Application
BES-Basic Energy Sciences
BLM-Bureau of Land Management
BOM-Bureau of Mines
BOR-Bureau of Reclamation
CEQ-Council of Environmental Quality
COMMERCE-Department of Commerce
DOD-Department of Defense
DGE-Division of Geothermal Energy
DOE-Department of Energy
DOI-Department of Interior
EIA-Energy Information Administration
EPA-Environmental Protection Agency
FERC-Federal Energy Regulatory Commission
FWS-Fish and Wildlife Service
GSFC-Goddard Space Flight Center
NASA-National Aeronautics and Space Administration
NFEC-Naval Facilities Engineering Command
NSF-National Science Foundation
OEP-Office of Energy Policy
OER-Office of Energy Research
ORAD-Office of Research and Development
OWRT-Office of Water Research and Technology
TREASURY-Department of the Treasury
USDA-Department of Agriculture
USFS-United State Forest Service
USGS-United States Geological Survey

*Denotes Chairing function

Figure 5.1-2. Responsibilities of Federal Agencies

AGENCY	IMPROVE RESOURCE ESTIMATES	LEASING OF FEDERAL LANDS	REDUCE COSTS AND RISKS (R & D)	PRODUCE ENERGY	STIMULATE ENERGY DEVELOPMENT	REGULATE ENERGY PRODUCTION
Department of Energy (DOE)						
Resource Assessment	Yes	Yes	Yes	Cost-shared demonstrations.	Set commercialization goals; loan guarantee program (GLGP).	Prepare EAR/EIS for DOE projects.
Environment			Yes			Review EAR/EIS.
Federal Energy Regulatory Commission						Power production decisions on geothermal projects.
Energy Research			Yes			
Department of Commerce (DOC)						
Economic Development Administration				Yes	Yes	
Department of Defense (DOD)			Yes	Yes		
Department of Housing and Urban Development (HUD)				Yes	Yes	
U.S. Department of Agriculture (USDA)						
Forest Service		Yes		Yes	Yes	Process non-competitive lease applications; review permits.
Department of Transportation (DOT)					Yes	
Department of the Interior (DOT)						
Bureau of Land Management (BLM)		Yes	Yes			Environmental review before leasing.
U.S. Geological Survey (USGS)	Yes	Yes	Yes			Monitor environmental impacts after leasing.
Fish and Wildlife Service (FWS)						Yes
Water and Power Resources Service (WPRS)	Yes					
Environmental Protection Agency (EPA)			Yes			

Source: Adapted from IGCC, Fourth Annual Report to Congress, June 1980, Tables IV.3 and IV,4)

by the Division of Geothermal Energy, Office of the Assistant Secretary for Energy Technology (now incorporated into the Division of Geothermal Energy, Resources Applications), will develop improved technologies with reduced costs for field development and energy conversion. Supporting regional environmental assessments and R&D activities are provided by the Division of Environment and Safety, Office of the Assistant Secretary for the Environment. In addition, designated representatives of other DOE offices participate in the activities of the IGCC Budget and Planning Work Group and panels of the Staff Committee.

Table 5.1-2. Federal Funding for Geothermal Energy, FY 1973 - FY 1980 (thousands of dollars)

ORGANIZATION UNIT	ACTUAL FY 1978	ACTUAL FY 1979	ESTIMATED FY 1980
Department of Agriculture			
U.S. Forest Service	678	775	750
Department of Defense			
Navy	542	924	17,100
Air Force	0	13	21
DOD Total	542	937	17,121
Department of Energy			
Energy Technology	105,962	142,637	138,428
Resource Applications		9,737	9,026
Office of Energy Res.	2,800	3,200	3,400
Environment	3,896	3,167	2,303
Geothermal Loan Guaranty Fund (Administrative Expenses)	410	189	1,180
DOE Total	113,068	158,930	154,334
Department of Interior			
Fish and Wildlife	200	200	74
Bureau of Land Mgmt.	2,300	2,585	2,600
Bureau of Mines	550	1,050	800
Water and Power Res.Serv.	1,800	555	910
Geological Survey, Geothermal Res. Program	10,184	12,043	10,092
Geological Survey, Geothermal Evaluation and Lease Regulation	1,854	2,194	1,994
DOI Total	16,888	18,627	16,470
Environmental Protection Agcy.	670	750	750
National Science Foundation	175	70	0
Total Federal Geothermal Program Budget	132,021	180,089	189,696

Source: Interagency Geothermal Coordinating Council, Fourth Annual Report on the Geothermal Energy Research, Development and Demonstration Program, June, 1980.

•Field Offices

Management of the commercialization program at the field level is assigned to matrix management teams typically containing staff from Operations Offices and the Offices of the Regional Representatives. These teams are delegated responsibility for implementation of the hydrothermal commercialization program in each DOE region. The field teams are directly responsible for the coordination of state commercialization planning programs, field experiments in direct heat applications, outreach activities, and other aspects of the program relating to local, state, or regional initiatives.

Table 5.1-3 describes DOE's Hydrothermal

Table 5.1-3. DOE Hydrothermal Programs, 1975-1980.

	DOE DIVISION	PROGRAM	START DATE	SUBPROGRAM / PROJECT DESCRIPTION
RESOURCES ASSESSMENT	Geothermal Energy (ET)	Hydrothermal Resources	1975	Resources Definition (in cooperation with U.S.G.S.
			1977	o
			1977	o
			1978	State Coupled Program
				o Definition of Low & Moderate temperature resources in cooperation with the California State Geologist.
				Phase I. Analysis of existing data. Phase II. Detailed Assessments of identified areas.
TECHNOLOGY ASSESSMENT	Office of Technology Impacts/ Office of Health & Environmental Research (EV)	Environment & Safety	1975	Imperial Valley Environmental Project
			1977	Geothermal Environmental Overview
				o The Geysers
				o Mono Long Valley
				o Coso Hot Springs
		Federal Programs Planning	1977	Geothermal Prospect Development Scenarios
	Geothermal Resources Management (RA)	Private Sector Development	1978	Marketing Analysis, Low-moderate temperature direct applications in 15 states.
				o California
		Planning & Analysis	1979	National Progress Monitoring
				Economic Studies & Federal Policy Analysis
RESEARCH, DEVELOPMENT, & DEMON-STRATION	Geothermal Energy (ET)	Geothermal Technology	1976	Drilling & Completion Technology Improvements
			1976	Energy Extraction, Conversion & Stimulation Technology
			1976	Energy Extraction, Conversion & Stimulation Technology
			1976	o Direct-contact heat exchanger, East Mesa, CA.
			1976	o Fluted tube condenser component test, East Mesa, CA.
				o The Geysers Stimulation Project
				o Testing of 500 KW skid-mounted binary system, East Mesa, CA.
			1976	Geochemical Engineering & Materials
			1976	Geosciences
	Division of Environmental Control Technology (DGE)	Facilities	1976	Geothermal Loop Experimental Facility, Niland, CA.
			1976	Geothermal Test Facility, East Mesa, CA.
			1977	50 MWe Demonstration plant
		Environmental Control Technology	1977	H_2S Emissions
				o Development & Testing of copper sulfate H_2S scrubber.
				o Geothermal Fluid Disposal
				o Land Subsidence
				o Seismicity
				o Noise
				o Well Blowouts

Table 5.1-3. DOE Hydrothermal Programs, 1975-1980.

	DOE DIVISION	PROGRAM	START DATE	SUBPROGRAM / PROJECT DESCRIPTION
RESEARCH, DEVELOPMENT, & DEMONSTRATION		Institutional Support	1977	Leasing & Permitting
		Hydrothermal Resources		Engineering Applications (PON)
			1978	o Livestock feed production, Kelley Hot Springs, CA.
			1978	o District heating, Susanville, CA.
			1978	o Prawn raising, Mecca, CA.
			1978	o Sugar processing, Brawley, CA.
			1978	o District Heating, El Centro, CA.
			1979	Feasibility Studies o Food processing industry
	Geothermal Resources Management	Private Sector Development	1977	Hydrothermal Applications: Engineering & Economics Studies
			1977	o Tungston Metal Processing, Bishop, CA.
			1977	o Corn milling plant, East Mesa, CA.
			1977	o Integrated livestock production, Wendel-Amedee, CA.
			1977	o Drying wood waste, Wendel-Amedee, CA.
			1977	o Agribusiness & Alternante Uses for exhaust heat, Lake Co., CA.
			1977	o Total Energy Recovery System for Agribusiness, Lake Co., CA.
			1977	o District Space & Water Heating, Mammoth Lakes, CA.
			1977	o Acquaculture, Desert Hot Springs, CA.
			1977	o Fertilizer Production, El Centro, CA.
			1978	o Multiple Use District, El Centro, CA.
			1978	o Multiple Use, Space & Water Heating & Cooking System, Susanville, CA.
COMMERCIALIZATION	Geothermal Resources Management	Geothermal Loan		Three Loan Guarantees
			1977	o Field Development, East Mesa, CA.
			1977	o Field Exploration, South Brawley, CA.
			1977	o Exploration & field development, Westmoreland, CA.
		Planning & Analysis	1979	State & Local Planning: California. Phase I. Funded support to the CRB/TAC; workshops by CEC on Geothermal project financing.
		Private Sector Development	1979	Outreach Program. Funded the Oregon Institute of Technology to provide technical consultation to prospective geothermal users.

Source: See References in Section 5.1.

* Only projects implemented in California are highlighted. See text in Section 5.1 for description of individual programs.

Commercialization Programs in the period 1975-1980. Program activities and projects in California are highlighted.

A brief description of the hydrothermal commercialization program under the former Division of Geothermal Resource Management (DGRM) is presented in Section 5.11, followed by summaries of the Geothermal Loan Guaranty Program** (Section 5.12), Energy Technology (Section 5.13), and Environment Programs (Section 5.14). These summaries will be organized according to their (1) Commercialization Issues, (2) Program Description, (3) Recent Activities, and (4) Future Developments. Current activities in California will be highlighted.

REFERENCES

1. Department of Energy, Solar, Geothermal Electric and Storage Systems, Program Summary Document, FY 1980, July 1979.

2. Department of Energy, Division of Hydrothermal Resources Management, Fiscal Year 1980 Multi-Year Program Plan for Geothermal Hydrothermal Resources, October 1979.

3. Department of Energy, Geothermal Energy Research, Development and Demonstration Program, Third Annual Report of the Interagency Geothermal Coordinating Council, March 1979.

**The Geothermal Loan Guaranty Program is an integral part of the DGRM Program. It is described separately at Section 5.12 primarily for reasons of clarity.

5.11 THE GEOTHERMAL RESOURCES MANAGEMENT PROGRAM

COMMERCIALIZATION ISSUES

A number of technical, economic, and institutional uncertainties are becoming increasingly critical as geothermal applications move beyond the demonstration stages at various sites:[1]

- How can reservoir performance be sustained over the economic life of facilities constructed to exploit the resource?

- Can the difficulties of locating potential users at identified resources for direct heat applications be mitigated or overcome?

- What federal and state environmental standards should be applied to geothermal activities?

- Can exploration and development of geothermal resources be conducted in presently undeveloped areas in a manner consistent with the preservation of recreational and wilderness values?

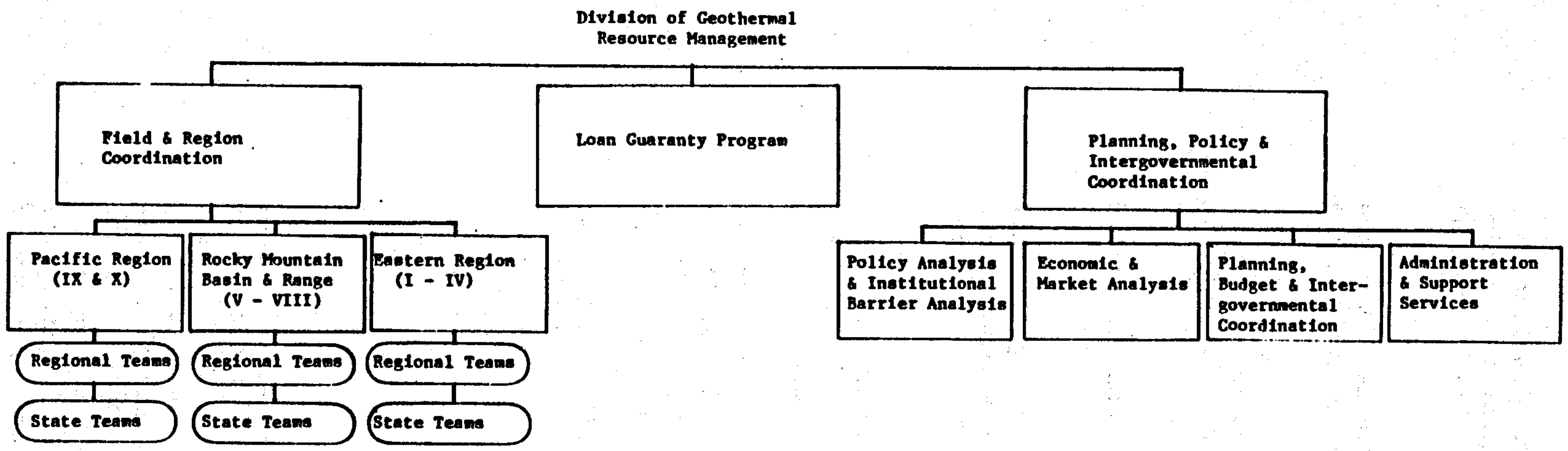
- Can the burdens on developers of overlapping, conflicting, and duplicative regulations for leasing and permitting geothermal development be reduced?

To address these issues and to create the program infrastructure for accelerating private sector participation, the Division of Geothermal Resource Management (DGRM) (now incorporated into the Division of Geothermal Energy) was established in 1978 to take primary responsibility for coordinating, planning, and implementing DOE's geothermal commercialization program. Its function was to provide a single focus within DOE for all matters concerning the commercial development and utilization of hydrothermal resources and to act as the principle source of information to upper management in DOE, and to other federal, state, and local agencies.

PROGRAM DESCRIPTION

The approach formulated by DGRM involves planning, implementation, and monitoring of time-phased, interrelated activities. The program contains two major elements. Planning and analysis activities within DGRM are carried out by an Office of Planning, Policy and Intergovernmental Coordination. Management of private sector development at the site, state, and regional levels is assigned to the Field and Regional Coordination Office through a network of Regional Coordinators. Figure 5.11-1 contains a summary of the organization of DGRM.

Figure 5.11-1. Organizational Structure - Division of Geothermal Resources Management



Source: Division of Geothermal Resources Management, FY 1980 Multi-Year Program Plan for Geothermal Hydrothermal Resources, Draft, October 1979.

The four subelements of the Planning and Analysis Program element were: (1) State and Local Planning, (2) National Progress Monitoring, (3) Interagency Coordination and Federal Policy Analysis, and (4) Economic Evaluation and Barrier Analysis. The subprograms of the Private Sector Development Program included: (1) Market Assessment, (2) Hydrothermal Applications, (3) Outreach Activities, and (4) The Geothermal Loan Guaranty Program. A brief review of FY 78-79 activities for DGRM is presented in the following section. Recent developments in California projects are highlighted briefly.* The history and development of the Geothermal Loan Guaranty Program is summarized separately in Section 5.12.

RECENT ACTIVITIES - PLANNING AND ANALYSIS

The Office of Planning, Policy and Intergovernmental Coordination was responsible for formulating and guiding the implementation of the federal program under the direction of the IGCC. In addition, this office developed a national plan and strategy for hydrothermal commercialization. The objective of this subprogram was to formulate coordinated geothermal commercialization plans at the local, state, regional, and national levels to guide development of each major geothermal prospect having an accessible market.

<u>State and Local Planning</u>

During FY 78-79, cost-shared geothermal development planning projects were initiated in 15 western states. In California, Phase I funded staff support to the Technical Advisory Committee of the Geothermal Resources Board, and sponsored a series of workshops dealing with financing of geothermal development. Phase II is now underway, and should include more specific planning and information dissemination activities directed to the needs of specific local governments and industry actors.

<u>National Progress Monitor</u>

The ultimate test of the federal commercialization program will be the extent to which the various program elements accelerate geothermal development. However, a basis for earlier evaluation of progress is needed for timely revision of program efforts, priorities, and objectives. Design of a computerized national progress monitoring system was initiated in FY 79 to monitor the rate of geothermal development and the impact of federal programs, and to identify emerging problem areas. Program criteria were developed to evaluate factors that express commercialization

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* For a more detailed description of California programs, see Section 5.24.

progress or have an identifiable impact on near-term goals. Under a Project Management System, additional activity measures were set up to evaluate the progress of federally supported projects on specific sites. Completion of system design and regional implementation were scheduled for the end of the first quarter FY 80.

Interagency Coordination and Federal Policy Analysis

During FY 79-80, this subprogram supported the IGCC and its panels and working groups through review of new regulations and coordination of federal geothermal budgeting and leasing activities. It also identified new policy measures and regulatory and legislative changes needed to support achievement of commercialization goals. The Geothermal Streamlining Task Force Report contained 19 recommendations for administrative, regulatory, and legislative changes to streamline geothermal leasing of federal lands and subsequent development activities. A geothermal Omnibus Bill was prepared by the Institutional Barriers Panel of the IGCC for submittal to the Office of Management and Budget.*

Economic Studies and Barrier Analysis

The objectives of the Economic Studies and Barrier Analysis Program were to establish overall market penetration potential for hydrothermal resources, to optimize marketing strategy, and to determine the impacts of federal, state, and local laws (or the lack of them) on commercialization.

During FY 79, the costs and benefits of current DOE R&D on geothermal electric power development were evaluated. Geothermal supply curves were developed for 37 specific sites for electric power generation, analyzing the impact of current R&D efforts. The decision processes of both larger and small developers were analyzed. In support of the increasing emphasis on direct use, a number of district heating cost models were developed and successfully tested for applicability against existing systems in Iceland and two sites in Utah.[2] In addition, relevant federal, state, and local laws and regulations were reviewed and recommendations developed for identified institutional barriers.

RECENT ACTIVITIES - PRIVATE SECTOR DEVELOPMENT

The Office of Field and Regional Coordination (FRCO) had the lead for private sector development activities and

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* Some of these reccomendations were included in the Energy Security Act of 1980; see description in Section 7.3 below.

acted as the clearinghouse for actual implementation of hydrothermal commercialization projects, either directly or through appropriate field offices.

Market Assessment

To establish the foundation for a marketing strategy, market studies were carried out during FY 79 in 15 western and 4 northern states to (1) define the potential direct use market, (2) predict the degree of market penetration as a function of locational energy supply and demand, (3) identify environmental constraints, legal barriers, institutional factors, and technical and financing limitations.[2] In addition, cooperative studies were initiated with a number of groups from the pulp paper and food processing industries to determine the feasibility of geothermal energy uses.

Hydrothermal Applications

The primary task of the Hydrothermal Applications Program was to stimulate developer and user participation and cost-sharing in feasibility analyses and direct heat utilization demonstration projects.

Eleven technical/economic studies for direct heat applications at specific sites were funded in FY 79 to be completed in FY 80. Of the eleven awarded, five concern institutional uses and district heating and the remaining six are for industrial applications. Industrial applications include a feedlot operation, nylon stockings manufacture, a frozen food factory, a sewage treatment plant, production of ethanol from farm products for use as a gasoline supplement, and tungsten metal processing. Each engineering and economic study must consider technical, environmental, legal, and cost-benefit aspects of tapping geothermal resources known or thought to exist near industrial sites.

Two projects located in California were selected:[3]

- Westec Services, Inc. of San Diego, in cooperation with Union Carbide Company, Bishop, California, for a study of tungsten metal processing in Bishop.

- Burns and Roe Industrial Service Corporation of Paramis, New Jersey, for a study of a corn milling plant in East Mesa, California.

Outreach Activities

A pilot-level outreach program to provide technical consultation to prospective geothermal resource users, public information on hydrothermal resources and their applications, and community assistance in development planning was initiated in FY 79 with the assistance of the Idaho National

Engineering Laboratory and the Oregon Institute of Technology. The National Conference of State Legislatures held workshops in ten states* to assist in development of legislation needed to encourage geothermal commercialization.**

Geothermal Loan Guaranty Program

The Geothermal Loan Guarantee Program is a major source of financial incentive for geothermal development. As of August 1979, it has approved four projects with guaranties totaling $43.4 million. Four applications were in process for another $88 million in loan guaranties, with additional requests expected. A more detailed description of the Loan Guaranty Program is provided in Section 5.12.

FUTURE DEVELOPMENTS

The Division of Geothermal Resources Management was established in FY 79 to implement the federal hydrothermal commercialization program. The strategy chosen for federal commercialization efforts combines tax and economic incentives, expansion of the Geothermal Loan Guaranty Program, reservoir identification and confirmation programs, hydrothermal technology development, and aggressive market definition, coupled with technical assistance and outreach programs to reach potential users. The proposed FY 80 budget level was designed to maintain the momentum generated by past activities so that adjustments in subsequent years can be made when FY 79 and FY 80 trends become apparent. (See Table 5.11-1)

More detailed descriptions of the supporting programs in Energy Technology (Division of Geothermal Energy) and Environment (Division of Environment and Safety) are presented in Sections 5.13 and 5.14.

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* Arizona, Connecticut, Delaware, Maryland, Nevada, New Mexico, Oregon, Vermont, Virginia, and Washington.

** Workshops in California were conducted by a number of state agencies. See Summary of California Workshops in Section 5.23.

Table 5.11-1 Office of Emerging Energy Sources-Resource Plan for Hydrothermal ($ in Thousands).

Major Activities	FY 1979 OBs	FY 1979 Costs	FY 1980 OBs	FY 1980 Costs
Planning & Analysis				
Site specific development plans	2163	2100	1500	1125
State and local planning support	1335	1335	1250	940
Interagency coordination	125	125	200	200
National progress monitoring	350	350	350	260
National and Federal program analysis	2185	2085	2200	1650
Federal policy analysis	275	275	480	360
Marketing				
User commitment initiatives	1550	850	790	590
Support infrastructure development	400	325	500	375
Outreach activities	740	660	900	675
Incentives outlays	385	340	500	375
International marketing	180	180	330	250
Total	9686	8625	9000	6800

Source: Department of Energy, Division of Hydrothermal Resources Management, Fiscal Year 1980 Multi-Year Program Plan for Geothermal Hydrothermal Resources, October 1979.

REFERENCES

1. Department of Energy, Division of Hydrothermal Resources Management, Fiscal Year 1980 Multi-Year Program Plan for Geothermal Hydrothermal Resources, October 1979.

2. Department of Energy, Solar, Geothermal Electric and Storage Systems, Program Summary Document (for Geothermal Energy), FY 1980, July 1979.

3. Geothermal Resources Council Bulletin.

5.12 THE GEOTHERMAL LOAN GUARANTY PROGRAM

COMMERCIALIZATION ISSUE

The availability of venture capital is critical to the commercialization of new energy technologies. At present, geothermal projects must compete with a limited track record on the rate of return on investment in the capital market.

PROGRAM DESCRIPTION

The Geothermal Loan Guaranty Program (GLGP) is a federal effort to promote new geothermal investments by assuming the ultimate financial risk for qualified projects, thus making them more attractive compared with other investment opportunities. The program is also designed to expedite development of normal borrower-lender relationships between the industry and the financial community. Financial institutions are encouraged to familiarize themselves with geothermal energy, thereby diminishing the level of perceived risk associated with a fledgling industry.

The GLGP was established under the Geothermal Energy Research, Development and Demonstration Act of 1974 (PL 93-410), and is administered by the Department of Energy (DOE).[1] The San Francisco Operations Office (SAN) of DOE has national responsibility for processing all loan guaranty applications for the program, which has been in effect since June 1976. DOE headquarters retains final approval responsibility, and the payment of guaranty obligations under the GLGP is backed by the full faith and credit of the United States.[2]

The GLGP is not a grant program. Financing arrangements are made with a commercial lending institution that is willing to make the loan subject to guaranty approval. The lender will evaluate the soundness of the loan, using criteria similar to non-guaranty loans. The maximum term of the loan will be determined by the expected average useful life of any major physical asset to be financed, the borrower's ability to repay based on cash flow projections, or 30 years, whichever is less.* A user fee will be charged of not more than 1% annually on the average outstanding loan balance. The project must be both technically feasible and environmentally acceptable. Finally, there must be reasonable assurance of repayment.

Under the terms of the act (and its amendments in PL 95-238), guaranties may be granted for up to 75% of the total project cost. The applicant must contribute at least 25% of the equity, and the total guarantied amount is

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* See Code of Federal Regulations, Section 790, G-H.

limited to $100 million per project, and $200 million per borrower. The funds may be used for any or all of the following purposes:

1. The determination and evaluation of the resource base;

2. Research and development on extraction and utilization technologies;

3. Acquiring rights to geothermal resources;

4. Planning, construction, and operation of facilities for the demonstration or commercial production of energy from geothermal resources.

In addition to guaranties, the law currently allows direct interest differential* payments to municipalities and other public entities using the Loan Guaranty Program that must raise debt through taxable obligations. The program will expire on September 3, 1984, with all loans guarantied prior to that date honored according to the loan agreement.

Priorities have been established for the evaluation of projects in the following order:**[3]

1. Projects with apparent potential for early development of geothermal energy;

2. Projects designed to utilize new technological advances or produce advanced technology components;

3. Projects which will demonstrate or exploit the commercial potential of new geothermal resource areas;

4. Projects initially proposing geological and geophysical exploration, or the acquisition of land or leases.

Furthermore, preferential consideration will be given to projects for which a lender provides a portion of the loan without government guaranty. Projects which provide royalities to the federal government, or which are carried out by small public and private utilities or small independently

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* Interest differential is the additional cost incurred by a public agency when issuing taxable debt obligations, as opposed to the non-taxable obligations that they usually issue. The amount will be the difference in market yields of the two issues, and in the event they are sold at face value, this will equal the difference in interest rates they bear.

** Proposed regulations may modify these priorities.

owned and operated businesses, also receive preference.

GLGP PROJECTS

As of February 1980, the GLGP has approved four projects with guaranties totaling $43.4 million. Four applications are in process for another $88 million in loan guaranties, with additional requests anticipated. Table 5.12-1 summarizes the GLGP activity to date.

Three of the approved projects to date have been in Imperial Valley, California. A combined generating capacity of 174 MWe is anticipated from exploration and field development at South Brawley by CU1, in the East Mesa by RGI, and at Westmorland by MAPCO.

Two electric applications and two greenhouse direct-use projects are currently being processed; two are in California. The Northern California Power Agency is requesting a guaranty of $47 million for its 110 MWe, Number 2 plant at The Geysers. The second application is the CUI field development follow-on at South Brawley in the Imperial Valley. An overview of current applications is presented in Table 5.12-2.

ACCOMPLISHMENTS AND RECOMMENDATIONS

Current and in-process guaranties presently total $104.2 million, with follow-on commitments of $153 million for the East Mesa project. This will support 339 MWe of geothermal electric potential; no estimates of energy use are available for the three direct-use projects. DOE has had preliminary discussions with potential applicants from California, Colorado, Hawaii, Idaho, New Mexico, Utah, and Wyoming. This growing level of GLGP activity suggests increased acceptance of the program by both lenders and borrowers.

In response to the growing interest of public agencies and small businesses in geothermal development for both electricity generation and direct heat uses, GLGP is now examining a number of actions to streamline the loan guaranty process. In addition, geothermal legislation introduced in the the Senate included several measures intended to maximize the usefulness of the program.* The

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* Senators McClure and Church of Idaho have introduced two different bills, S. 1330 and S. 1388, respectively. In the House of Representatives, Rep. Santini has introduced H.R. 6080. These bills were consolidated within the Energy Securities Act, described in Section 7.3.

Table 5.12-1 Summary of Projects Approved to Date under the Geothermal Loan Guaranty Program

BORROWER	LENDER	GUARANTY	PROJECT	LOCATION	RESULTS
Republic Geothermal, Inc.	Bank of America	$ 9,017,000	Resource exploration and testing	East Mesa, California	Drilled 4 reinjection and 7 production wells. Temperature 160-168° C at wellhead when pumped. USGS agrees that project can produce 64 MW for 25 years.
Westmorland Geothermal Associates	Bank of America	$29,100,000	Resource exploration, testing, and full field development	Westmorland, Imperial County, California	Guaranty recently awarded; exploration beginning.
Geothermal Food Processors, Inc.	Georgia State State Teachers Retirement System	$ 3,500,000	Process heat to dry agricultural products	Brady Hot Springs, Nevada	Plant operational and running at 88-100% of capacity. Drying contracts sufficient to repay debt. Back-up well flow affecting production well.
CU-I	Bank of Montreal (California)	$ 1,800,000	Resource exploration and testing	Brawley, Imperial County, California	One production well drilled to 14,000 feet, wellhead temperature of 232°C. salinity of over 269,000 ppm.

*Figures are current as of February 1980.

Source: Interagency Geothermal Coordinating Council, Fourth Annual Report on the Geothermal Energy Research, Development and Demonstration Program, June 1980.

Table 5.12-2 Current GLGP Applications*

Project	Type	Cost ($ millions)	Guaranty
1. CU-I South Brawley, CA.	Electric - Field Development	$ 78.8	$ 49.4
2. NCPA, The Geysers	Power Plant	56.2	47.1
3. Oregon Trail Mushrooms, Vale, OR.	Mushroom Plant	6.2	4.7
4. R&R Energies, Inc, Cove Fort, Utah	Ethanol Plant	4.0	3.0

Source: Interagency Geothermal Coordinating Council, Fourth Annual Report on the Geothermal Energy Research, Development, and Demonstration Program, June 1980.

*Figures are current as of February 1980

individual proposals will be discussed below.

Reduced equity requirement

Since public agencies face difficulties in raising the required 25% GLGP equity and cannot receive investment tax credit incentives under the National Energy Act, it is proposed that guarantees of 90% be authorized to put them on parity with private investors. Small businesses would also be allowed the increased coverage, primarily as a device to stimulate their geothermal development activities.

Elimination of requirement for borrower default

Utilities have been reluctant to participate in the GLGP because its current regulations require them to default before a loan would be repaid. The importance of their credit ratings and the effect of default on these ratings are significant deterrents to GLGP participation. It has been proposed that DOE be allowed to assume loans upon request, thereby alleviating utility hesitation.

In addition, an ongoing effort is made by DOE management to streamline the GLGP applications process for direct-use projects and to integrate the program with other commercialization programs. The GLGP is the last phase of cost-shared government support, which includes both funding for feasibility studies and field demonstration projects.

The linkage of the GLGP with other commercialization measures should faciliate the transition from one level of risk (and the associated need for government support) to a lower one.

REFERENCES

1. The Geothermal Energy Research, Development, and Demonstration Act of 1974, P.L. 93-410.

2. The Energy Research and Development Administration Authorization Act of 1977 and 1978, P.L. 95-238 (those portions pertinent to the GLGP).

3. Federal Register - vol. 41, no. 103, May 26, 1976, Title 10, Chapter III (ERDA), Part 790.4.

4. Louise Nasr, The Geothermal Loan Guarantee Program and Its Impact on Geothermal Exploration and Development, Colorado School of Mines, Golden, Colorado, May 1978.

5. Mark Silverman, The Geothermal Loan Guarantee Program U.S. Department of Energy, Direct Utilization of Geothermal Energy: A Symposium, January 31, 1978 to February 2, 1978, San Diego, California.

6. Geothermal Energy Omnibus Legislation, Recommendations of the Institutional Barrier Panel to the International Geothermal Coordinating Council.

7. DOE - GLGP Program Overview.

5.13 GEOTHERMAL/HYDROTHERMAL TECHNOLOGY DEVELOPMENT - DIVISION OF GEOTHERMAL RESOURCES

COMMERCIALIZATION ISSUE

Technology development is expected to affect commercialization of geothermal resources for about seven to ten years after its inception.[1] Research and Development conducted by DOE during the 1970s is providing the technology base for present growth through the mid-1980s. To encourage geothermal development, DOE has sponsored activities to define resources potential, reduce technical uncertainties, and improve the cost competitiveness of hydrothermal resources. The major impact of the current R&D program will be on longer term development.

TECHNOLOGY TRANSFER

An integral part of the DGE program strategy is to ensure the transfer of knowledge and technology by involving end-users in the development of the information. Conventional information dissemination techniques, such as report distribution, workshops and conferences, news releases, etc., are used in the program. In addition, there is active involvement in most projects and procurement actions of commercial entities that are likely to ensure the future commercial availability of the technology.

PROGRAM DESCRIPTION - DIVISION OF GEOTHERMAL ENERGY

Three programs are currently being carried out by the Division of Geothermal Energy (DGE) (now a part of the Division of Geothermal Energy, under the Assistant Secretary for Resources Applications)*: (1) Hydrothermal Resources, (2) Geopressured Resources, and (3) Geothermal Technology Development.** Table 5.13-1 provides the funding levels by programs for FY 1978 through FY 1980.

The emphasis of the Geopressure Resources Program is presently on exploration and resources confirmation and is

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*See update on DOE reorganization in Section 7.3.

** The description of the Hydrothermal Program is excerpted in part from the Solar, Geothermal, Electric and Storage Program Summary Document for FY 1980, prepared by the Assistant Secretary for Energy Technology and the Third Annual Report of the Interagency Geothermal Coordinating Council. For a more recent description, see Interagency Geothermal Coordinating Council, Fourth Annual Report, Geothermal Energy, Research, Development and Demonstration Program, June 1980.

Table 5.13-1. Geothermal Program Funding Levels, FY 1978 through FY 1980 (thousands of dollars)

Programs	Actual FY 1978	Estimate FY 1979	Estimate FY 1980
Hydrothermal Resources	55,000	70,900*	59,100
Geopressured Resources	16,400	27,700	36,000
Geothermal Technology Development	34,400	57,600**	43,900
Total	105,800	156,200	139,000

Source: Department of Energy, Assistant Secretary for Energy Technology. Solar, Geothermal, Electric and Storage Systems Program Summary Document - FY 1980, July 1979.
*Funding for the Regional Planning element of this program was transferred to the Division of Hydrothermal Resources Management, (RA).
**Funding for the Interagency Coordination and Planning element of this program was transferred to the Divison of Hydrothermal Resources Mangement, (RA).

not included in the following description because it is beyond the scope of this report. A brief summary of the Geothermal Technology Development Program is included below, under a separate section on Future Activities, to highlight longer term impacts on commercialization of hydrothermal resources.

Hydrothermal Resources Program

The strategy for the DGE Hydrothermal Program has been to pursue a mix of short and medium term goals which will expand the use of high-temperature resources while simultaneously establishing the technology which will allow development of the more prevalent moderate temperature resources. This involves:

- Resources Definition: confirm and assess geothermal prospects in cooperation with industry.

- Engineering Applications (the Program Opportunity Notice Program): assist cost-shared direct-use field experiments which demonstrate the practical and economic applications of moderate temperature resources.

* Environmental Control (in cooperation with the Office of the Assistant Secretary for Environment): examine issues associated with geothermal development; establish environmental control research and monitoring programs; and support preparation of Environmental Impact Assessments and Environmental Impact Reports.

* Facilities: Maintain experimental facilities to perfect equipment, materials, and techniques use to exploit hydrothermal resources, particularly for generating electric power.

* 50 MWe demonstration power plant (Valles Caldera, NM): establish the commercial feasibility of electric power production from high-temperature, moderately saline geothermal fluids. This plant will establish the technical and economic viability of the technology at full commercial scale; this cost-shared project was awarded after a competitive solicitation.

Table 5.13-2 presents the funding level for the Hydrothermal Resource Program. A brief discussion of recent activities in each of the subprograms appears below.

Table 5.13-2. Hydrothermal Resources Funding Levels by Subprograms, FY 1978 through FY 1980 (thousands of dollars)

Activities	Actual FY 1978	Estimate FY 1979	Estimate FY 1980
Resources Definition	14,400	25,470	9,000
Engineering Applications**	7,800	10,500	9,831
Environmental Control	1,600	516	1,300
Facilities	26,100	27,169	32,069
Capital Equipment	1,200	1,400	800

Source: Department of Energy, Assistant Secretary for Energy Technology, Solar, Geothermal, Electric and Storage Systems Program Summary Document - FY 1980, July 1979.
**Includes $4 million for second demonstration plant.

RECENT ACTIVITIES

Resource Definition

The Geothermal Steam Act of 1970 assigned the U.S. Geological Survey (USGS) primary responsibility for long-term assessment of the nature, distribution, and energy potential of national geothermal resources. DOE's Resources Definition

Subprogram includes three basic elements.* The first is regional and national assessment of the hydrothermal resource in cooperation with the USGS. With DOE support, the USGS has updated its original assessment of U.S. geothermal resources.

The second element is confirmation of geothermal reservoirs with apparent commercial potential for producing electricity. Under the Industry-Coupled Program, exploratory drilling costs are shared with industry in exchange for publication of reservoir data.

Third, under the State-Coupled Program, low and moderate temperature resources (for direct heat application) are being defined in cooperation with 28 of the 37 states that have been identified as having resource potential. This includes analysis of existing geological and geophysical data to establish the existence and location of hydrothermal resources under Phase I.

Phase II provides more detailed assessments of identified areas. This phase may include the drilling of deep holes to confirm the existence and nature of the resources.

In California, the Division of Mines and Geology has prepared a map showing low and moderate resources in the state based on accumulated information under Phase I. Phase II may involve drilling of shallow wells at both Calistoga and Paso Robles to confirm the character of hydrothermal resources in these areas.**

Engineering Applications

There has been little use of geothermal energy for nonelectric purposes in the United States, except for a few cases of space and water heating for commercial and residential buildings, certain industrial uses, such as food-processing, and agricultural.

Through the Program Opportunity Notice (PON), DOE is sponsoring field experiments, on a cost-sharing basis, that

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*Under its pre-commercial program, DOE has also cooperated with the USGS in an effort to confirm the existence of suspected hydrothermal reservoirs. To date, activities have included drilling at Mt. Hood, Oregon, and the Snake River Plain, Idaho. The program will be discontinued in FY 1980 because new incentives in the NEA are expected to encourage industry to pursue the confirmation of hydrothermal resources.

**See also discussion in Section 5.24.

demonstrate the direct utilization or combined electric and direct use of geothermal energy. These demonstrations are intended to provide (1) examples of profitability of various nonelectric applications in a number of geographic regions, and (2) additional technical, economic, institutional, and environmental data under actual operating conditions.

DOE has spent or obligated approximately $25.55 million to carry out 22 PON projects in FY 1978-1981, with the government share varying from 22% to 80% of total project costs.

The five field experiments contracted in California are briefly described below.

- Direct Applications at Kelly Hot Springs

  Using two wells at Kelly Hot Springs, the Geothermal Power Corporation will demonstrate a geothermal direct energy application to a livestock feed production system and hog feed lot operation. The government will provide 30% of the $6,000,000 total cost.

- District Heating, Susanville

  The city will use the Susanville geothermal resource to provide space heating to 17 existing public buildings. A parallel effort will involve expansion of the city system and development of a commercial park. The government will provide 45% of the $4,300,000 total cost.

- Aquafarms International, Mecca

  A commercial fish farmer will expand an existing geothermally supplied system to raise giant Malaysian prawns. The government will provide 33% of the $1,090,000 total cost.

- Holly Sugar Geothermal Project, Brawley

  This project involves the design, installation, and operation of a geothermal energy system to be used directly for process heat at the Holly Sugar Refinery. The government will provide 22% of the $18,000,000 total cost.

- Geothermal District Heating, El Centro

  Geothermal resources from the Heber KGRA will provide space cooling and heating and domestic hot water to the community center at El Centro. This project will serve as the core for a future district heating and cooling system for the city. The government will provide 27%

of the $2,650,000 total cost.

Environmental Control

The Environmental Development Plan (EDP) for Geothermal Energy Systems has identified a number of environmental, health, and safety problems associated with geothermal development. Release of hydrogen sulfide (H_2S) is a major air quality nuisance. Hydrogen sulfide has an offensive odor and may cause corrosion of exposed metal. Withdrawal of fluids from reservoirs may cause land surface subsidence. Seismic disturbances may result from fluid extraction and injection processes. Fluid disposal or spills may contaminate surrounding surface areas or groundwater. In addition, geothermal activities may produce noise levels unacceptable to nearby communities.

DGE has established several research programs to address these environmental problems.* Issue definition studies were conducted for liquid waste disposal, noise, and well blowout. The first two studies began in cooperation with the Division of Environmental Control Engineering. Environmental control research programs currently deal with H_2S emissions. One such system, a scrubber using copper sulfate, was successfully tested at The Geysers geothermal field in FY 77. Removal efficiencies for H_2S exceeded 99% with this scrubber; it also extracted ammonia and boric acid in large quantities. A commercial-scale scrubber was tested in FY 79 at the Geysers.

In addition to environmental control studies, DGE sponsors environmental monitoring for each of its major field projects. The monitoring part is to support preparation of Environmental Impact Assessments/Statements (EIA/EIS), as required by NEPA regulations. To assist with EIA/EIS preparation, DGE has developed guidelines for environmental reports by contractors. Finally, DGE also encouraged the adoption of consensus standards and environmental performance criteria. Definition of work standards is carried out in cooperation with the Division of Operational and Environmental Compliance, and with state and local agencies.

FACILITIES

DOE supported a number of facilities to demonstrate that electric power generation from hydrothermal resources is technically feasible, economically sound, and environmentally acceptable.

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* See also description of the Environment and Safety Program, Section 5.14 below.

Raft River Pilot Plant, Idaho

This project is a 5-MWe binary cycle plant that uses a Rankine cycle to convert energy from a moderate-temperature hydrothermal resource (300°F) to electricity.

Construction began in FY 78. Major equipment will be delivered by February 1980. The supply and injection wells and surface piping have been completed; well testing has begun. Plant operation is scheduled to begin early in FY 1981.

Hawaii Geothermal Wellhead Generator

The objective of this project is to establish the feasibility of using wellhead generators to produce base-load electrical power. The technology would be especially useful in remote areas. The project is jointly funded by DOE and the Hawaii Geothermal Project Development Group, which includes the State of Hawaii, the county of Hawaii, the University of Hawaii and the Hawaiian Electric Company. Conceptual and preliminary designs of a 5 MWe wellhead generator were completed in FY 79. Geothermal fluid for a 3 MWe test generator will be supplied from an existing geothermal well in the Puna district on Hawaii. The unit will be started in FY 81 and will operate for about two years.

Geothermal Loop Experimental Facility (GLEF), Niland, CA

The first GLEF was constructed in 1975. It was designed to establish the feasibility of flash steam/binary systems in the production of electric power from high-temperature/high-salinity resources. Project cost was shared equally between DOE and the San Diego Gas and Electric Company. The facility operated 1,000 hours before it was shut down for removal of accumulated scale. New plant designs to reduce downtime for incorporating redundant flash trains are expected to increase the plant's production capacity from below 75% to over 85% and reduce energy production costs to below 38 mills/kWh in the 50 MWe size.

Recent studies at the site have also produced effective pre-injection treatments to eliminate injection clogging problems. Facility testing was completed in FY 79.

Geothermal Component Test Facility (GCTF), East Mesa, CA

This facility provides high-temperature, moderate-to-low salinity geothermal fluid and supporting services to experimenters for R&D testing of equipment and components to be used in advanced geothermal systems. The GCTF is currently used to test both federally and commercially developed components. Operation will continue as long as there is sufficient demand by industry.

Demonstration Plant, Baca Ranch, Valles Caldera, New Mexico

In FY 77, Congress authorized a DOE geothermal demonstration project using a hot water hydrothermal resource. The project entails construction and operation of a commercial-scale (nominal 50 MWe) electric power plant. A cooperative cost-shared agreement was signed in August 1979 with the Union Oil Company of California and the Public Service Company of New Mexico for the construction and operation of the demonstration plant at Valles Caldera, New Mexico. The demonstration plant is scheduled for operation in the second quarter of FY 82. It will provide technical data and financial operating experience for a commercial-scale enterprise.

FUTURE DEVELOPMENTS - GEOTHERMAL TECHNOLOGY DEVELOPMENT PROGRAM

DOE's technology development efforts focus on reducing the costs of geothermal exploration, development, and utilization. Table 5.13-3 presents the funding levels by subprograms for FY 78 through FY 80.

Table 5.13-3 Geothermal Technology Development Funding Levels by Subprograms, FY 1978 - FY 1980 (thousands of dollars)

Activities	Actual FY 1978	Estimate FY 1979	Estimate FY 1980
Drilling and Completion Technology	2,300	6,000	7,000
Energy Conversion Systems and Stimulation	11,100	13,100	10,000
Geochemical Engineering and Materials	3,600	6,000	3,700
Geosciences	7,100	11,700	4,200
Hot Dry Rock	5,900	15,000	14,000
Capital Equipment	1,300	1,500	2,100

Source: Department of Energy, Assistant Secretary for Energy Technology, Solar, Geothermal, Electric and Storage Systems Program Summary Document - FY 1980, July 1979.

The program consists of elements that complement the development of a geothermal resource. Drilling and completion technology improvements could reduce the cost of geothermal wells 25% by 1983 and 50% by 1986. Current research to improved drill bits, downhole motors, and drilling fluids will affect the drilling costs of the projected 8,000 wells that must be drilled to bring 20,000 MWe of geothermal power on-line.

The Energy Extraction, Conversion and Stimulation Technology Subprogram is developing pumps, heat exchangers, and power systems to use moderate-temperature geothermal fluid for economical production of electricity.*

Several ongoing programs will improve the performance and reduce costs of binary heat exchangers. Heat exchangers account for 50 to 70% of binary plant costs and also strongly influence the efficiency and cost of binary systems. Also included in this subprogram are testing and evaluation of a 1.2 MWe helical screw expander wellhead generator system. The helical screw expander will be tested both domestically and in Mexico, Italy, New Zealand, and Turkey under the auspices of the International Energy Agency.

Stimulation is a way to increase production from an individual well, reducing the number of wells required to exploit a reservoir. Two major efforts in stimulation were initiated in FY 79:

- A $4.5 million contract to plan, manage, and implement stimulation research and field testing which will support laboratory and field studies of formation acidizing and fracturing;

- Explosives are being used to stimulate a Union Oil geothermal well at The Geysers to increase the steam flow rate from 80,000 to 150,000 lb/hr. DOE and several developers share the costs for this effort.

The Geochemical Engineering and Materials Subprogram addresses the special character of geothermal fluids and their interaction with other materials. Program areas include fluid handling to control scale formation and injection well plugging, high-temperature seals, new instrumentation sensors for high-temperature corrosive environments, and development of improved materials, such as well cement.

Electric materials and sampling and analysis handbooks were completed during FY 78. Industrial oversight of

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* Technology for moderate-temperature resources is being emphasized because they constitute a much larger resource base than high-temperature resources, but will be more difficult to utilize economically.

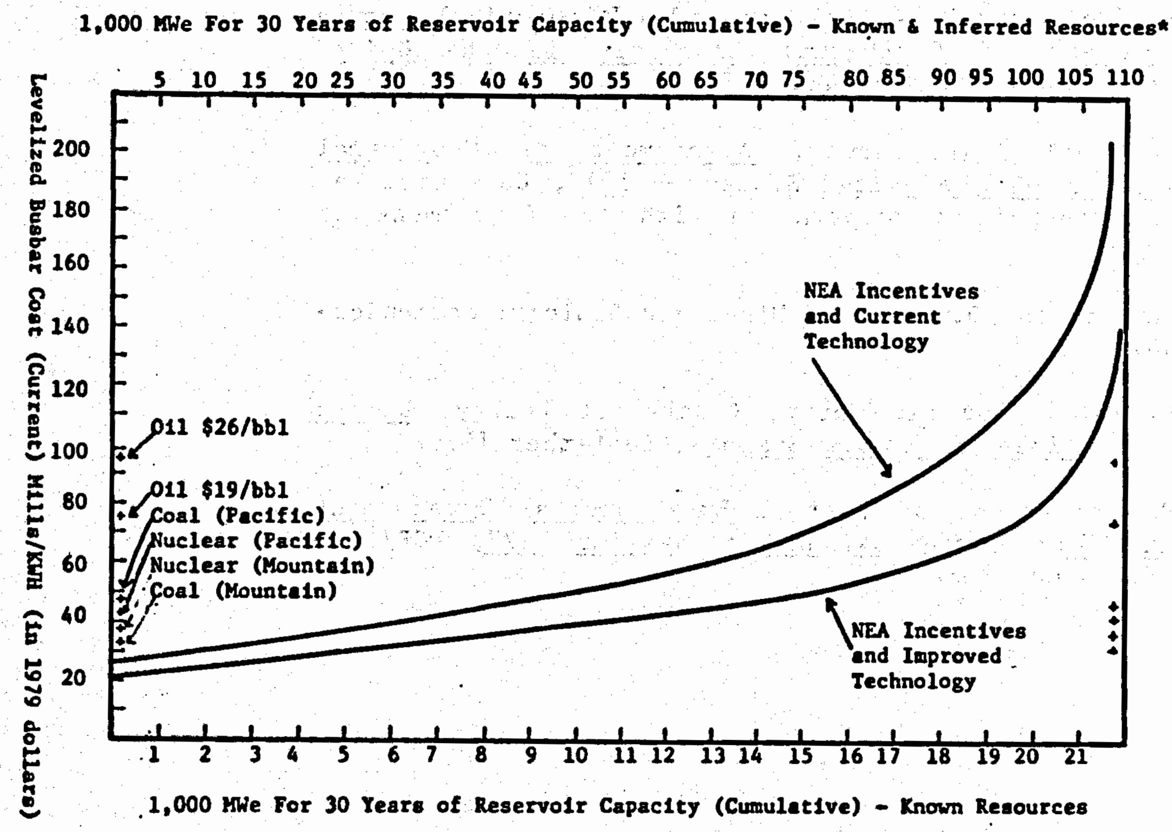
projects to improve materials in high-temperature cements and seals were initiated in FY 79 with the cooperation of the American Petroleum Institute and the American Society for Testing and Materials. Corrosion-resistant polymer concrete and 260°C elastomer seal materials were also successfully tested. Future plans include developing fluid monitoring and control instrumentation for fluid and gas handling and disposal, and developing technology necessary to establish fluid handling and system materials standards.

The Geoscience Subprogram aims to improve the technologies for exploration, reservoir engineering, logging instrumentation, and log interpretation. The principal area of effort in FY 78-79 was logging technology, which focused on development of: (1) high-temperature (up to 350°C) instrumentation, and (2) advanced interpretation techniques for logging. High-temperature circuitry and upgraded tools to measure temperature, pressure, and fluid flow were successfully demonstrated in a 275°C well at Valles Caldera, New Mexico. The program for log interpretation will provide calibration of test wells for industrial use, comparative commercial logging of test wells, and depositories for cores and log records.

The Hot Dry Rock (HDR) Subprogram assesses the potential of the HDR resource and supports development of new technical approaches for making commercial use of HDR energy. Presently, this subprogram consists of a successful experimental loop at Fenton Hill, New Mexico, and a national assessment of HDR potential.

The effectiveness of the federal R&D program has been estimated in terms of its impact on the cost of electric power for known and inferred hydrothermal resources. Federally-sponsored R&D is expected to significantly expand the number of resources which can be developed at costs competitive with other energy sources. The upper curve of Figure 5.13-1 shows the estimated busbar cost in mills/kWh (1978 dollars), with the use of current technology and economic incentives available under the National Energy Act. The lower curve presents the estimated cost reduction from improved technology based on goals set for existing federal R&D programs.

Figure 5.13-1. Market/Economic Readiness of Geothermal Hydrothermal: Impact of NEA Plus Improved Technology on Projected Costs



* Does not include The Geysers. Upper horizontal axis assumes inferred sites to come in at cost of and in proportion to discovered sites. (Based on USGS estimates.) Assumptions for this table are discussed in Appendix D.

Source: Interagency Geothermal Coordinating Council, Fourth Annual Report on the Geothermal Energy Research, Development and Demonstration Program, June 1980.

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5.14 THE ENVIRONMENT AND SAFETY PROGRAM*

COMMERCIALIZATION ISSUE

Accelerated development of energy sources will require some coordination mechanism to address environmental, health, and safety concerns. Past failures to provide for adequate resolution of environmental impacts has led to costly court battles and other protests. Contributing factors to such impasses that have been identified include:

- Lack of an adequate data base. In many cases, adequate information has not been developed or is not available in a form suitable to assure decision-making groups that development impacts are understood.

- Inadequate mechanism for information dissemination. Even when adequate exists, there may be no means to distribute that information information to groups involved in the decision-making process.

- Lack of systematic, early involvement of decision-making groups in the identification of environmental concerns.

PROGRAM DESCRIPTION

The Environment and Safety Program was established to reduce environmental barriers to development of geothermal energy. The basic assumption of the program is that early involvement of all decision-making groups in the planning process for environmental effects will reduce or eliminate uncertainty associated with development. Informed participation of interested parties is expected to yield (1) early identification of environmental risks associated with development as specific sites; (2) clearer guidelines and regulations for development; (3) assignment of development priorities, including go/no-go judgments.[1]

Imperial Valley Environmental Project

The Imperial Valley Environmental Project (IVEP) was established in 1975 in anticipation of large-scale geothermal development in this rich agricultural area.** The

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* The authors would like to acknowledge the assistance of Messrs Calvin Jackson and Lowell Miller of DOE San Francisco Operations Office in the preparation of this section.

**The occasion for the project was an arrangement between ERDA (now DOE) and the San Diego Gas and Electric Company to jointly fund a geothermal test facility in the Imperial Valley.

project called for (1) the compilation of a comprehensive baseline of environmental conditions prior to the full-scale development of geothermal power; and (2) the development of a regional assessment of environmental impacts, assuming the development of 500 MWe of power at each of the four geothermal anomalies.

The goal of the project was to involve all Valley stake-holders (local, state, and federal agencies and the public) in the development of a comprehensive environmental data base as a planning tool in geothermal decision-making. Contractor management for the project was provided by Lawrence Livermore Laboratory, with overall management and coordination provided by ERDA-SAN (now DOE-SAN) and the Assistant Secretary for the Environment (EV).

The IVEP was in many ways a pilot project for the assessment of environmental impacts from geothermal development. What was learned from the IVEP was subsequently applied to other geothermal areas under the Geothermal Environmental Overview Project.

Geothermal Environmental Overview Project

The basic purpose of the Geothermal Environmental Project is to identify, summarize, and assess the environmental issues in areas currently identified by the Division of Geothermal Energy, DOE, as having high possibilities for commercial development. The Geothermal Overview Project addresses issues pertaining to air quality, ecosystems quality, noise effects, geological effects, water quality, socioeconomic and health effects. For each region studied, the following tasks were accomplished: (1) identification of key issues, (2) inventory of all available data, (3) analysis and assessment of available data, and (4) identification of additional information required for adequate assessments.

Free and open flow of information was fundamental to the overview project. By involving all parties* from the beginning, the overview report provided a representative survey of these groups. Another objective was to avoid redundancy by clearly establishing the status of current and planned research, including environmental baseline measurements and effects studies.

Implementation of the overview project has been accomplished through contracts to a number of groups, with

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* This included local, state, and federal agencies, electrical utilities, resource developers, universities, private and public groups.

overall management responsibilities assigned to the Lawrence Livermore Laboratory. Contractors are required to be located reasonably close to the region under study so that working relationships can be established with the industry participants and the government agencies responsible for planning and regulation. The contractors for geothermal resource areas in California are:

The Geysers-Calistoga area; Lawrence Livermore Laboratory (in cooperation with Sonoma, Lake, Mendocino, Napa Counties through the Geothermal Resources Impact Project),

Mono-Long Valley area; University of California, Los Angeles,

Coso Hot Springs; U.S. Navy.

Advisory committees have been established for each study. Membership has included experts associated with the development or management of the various geothermal resources. The advisory committees were charged with identifying all appropriate participants, planning workshops, and reviewing reports. Participants typically have included representatives from the:

Federal Government; Geological Survey, Bureau of Land Management, Environmental Protection Agency, Fish and Wildlife Service, Forest Service, Department of Agriculture, Department of Energy.

State Government; Air Resources Board, Energy Commission, Division of Oil and Gas, Land Commission, Railroad Commission, Department of Health, Public Utilities Commission.

Local Government; Planning Department, Public Works Department, Air Pollution Control District, Multi-county regional groups, Agriculture Commissioner.

Developers; Electric utilities, resource developers (steam, hot water, suppliers, etc.).

Others; Universities, private environmental laboratories, national laboratories, environmental groups.

A workshop approach has been used to involve participants in identifying key issues and priorities. Participants have often represented the expertise available in each project area.

The workshops were designed to review current knowledge and on-going or proposed environmental programs. Usually one day was required for such a review, with a second day spent in small groups to identify specific issues and requirements. This approach has been very successful in surfacing information that could not be conveniently obtained by other methods. The specific subcontractor is responsible for evaluating all data and developing a comprehensive report. These reports have been made available to local, state and federal agencies, utilities, developers, and public groups.

STATUS OF ENVIRONMENTAL ASSESSMENT ACTIVITIES IN CALIFORNIA

Imperial Valley Environmental Project (IVEP)

The baseline study was completed during FY 78. The regional assessment was completed by the end of FY 79. Approximately $6 million has been spent to date. IVEP has helped determine that geothermal energy can be developed in harmony with existing agricultural and recreational resources in the Imperial Valley. Project progress reports have uncovered no "stoppers" in the way of development.

The Geysers Overview

Next to the Imperial Valley, the highest priority KGRA in the nation is the Geysers-Calistoga area, 90 miles north of San Francisco. While over 700 MWe are currently being produced from the geothermal steam reservoir, environmental controversy has raised concern that the full potential of more than 2,000 MWe may never be realized. The Geothermal Environmental Overview Project in The Geysers was a first step toward identification of critical environmental issues. A final Preliminary Assessment Report has been issued which identifies the key environmental concerns.[4]

Mono-Long Valley and Coso Hot Springs Overview

A Preliminary Assessment Report has also been completed for the Mono-Long Valley area.[5]

Workshops have been held and a final report is nearing completion*[6] of environment impacts resulting from continued development in Coso Hot Springs.

Program Impacts

The principal benefits of the Geothermal Overview Process in California have been environmental characterization of four geothermal regions. In the Imperial Valley, the extensive environmental data base is playing a significant part in the regulatory process by serving as a master

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* See also update on status of development at Coso, Section 7.2 below.

environmental assessment of the Valley region. The data is being used by developers to obtain permits in a timely manner, and by local, state, and federal agencies to make land-use decisions. The list of projects underway or planned in the Imperial Valley attests to the effectiveness of the IVEP in reducing regulatory and permitting uncertainties. At The Geysers, the stage has been set for the implementation of a major project to draw together the fragmented environmental R&D projects into one integrated program effort. In the Mono-Long Valley area, a "go-slow" sign has been raised as a result of the many sensitive issues revealed. At Coso, the Navy is proceeding with development planning.

These preliminary assessments have provided decision-makers for the first time with a comprehensive view of the environmental situation in the areas studied. More importantly, the assessments also have provided a sound base from which to deal with environmental problems on a regional basis according to the anticipated scale of development and the available decision-making process. A summary of the recommendations for further research and monitoring at Imperial Valley, The Geysers, Mono-Long Valley and Coso is presented in Table 5.14-1.

FUTURE DEVELOPMENTS

Imperial Valley Environmental Project

DOE has been involved in the development of an IVEP transfer plan which would provide for a continuation of the monitoring of selected environmental parameters until geothermal power comes on-line in the Imperial Valley. This effort was designed to permit the primary data base to be applied to spot potential problems. The transfer plan calls for direct management and coordination of all on-going measurement activity to be transferred from DOE to Imperial County. While the framework for this transfer is now in place, certain monitoring activities specified in the transfer plan have yet to be finalized. Other issues to be resolved include a definition of DOE's role in providing continuing environmental support to geothermal commercialization efforts and the transfer of the extensive data base developed by the Lawrence Livermore Laboratory.

Geothermal Overview Project

Despite the fact that the geothermal Environmental Overview Project has been in place for three years, it is not clear at this time where the program fits within the existing DOE structure or the commercialization program. The program does provide information useful in making NEPA determinations, and serves to identify environmental, health and safety barriers to commercialization efforts. However,

Table 5.14-1. Recommendations for Further Research and Monitoring for Evaluation of Environmental Impacts Resulting from Development of Geothermal Resources in California.

AREA	HIGH PRIORITY ISSUES	RECOMMENDATIONS	MEDIUM PRIORITY ISSUES	RECOMMENDATIONS	LOW PRIORITY ISSUES	RECOMMENDATIONS
Imperial Valley*	Cooling tower drift	o Studies to determine area of impact (emis-	Induced seismicity	o Continued monitoring	Noise	o Mitigate with appropriate abatement technology
		o Studies of ecological effects	Effects on Salton Sea	o Continue to monitor to validate current assessment		
	Air quality	o Continued monitoring to validate current air quality assessment				
	Water quality	o Continued monitoring				
The Geysers-Calistoga KGRA	Control of H_2S emissions	o Development of abatement technology	Data and information storage	o Establishment of centralized data base	Effects of H_2S on health	o Studies of the effects of chronic exposure on behavior
		o Studies to predict pollution: Emission measuring Meteorological measurements Model development Model validation and prediction		o Chronic effects of low levels of H_2S on wine grapes and orchard crops		o Epidemiologic studies
					Accidental spills	o Monitoring
				o Literature search: effects of H_2S on wine quality	Water resources management	o Study of water and waste disposal required
		Air quality monitors	Long-term effects on the ecosystem	o Collection of baseline data	Particulate emissions	o Analysis of particle composition
	Noise control	o Development of abatement technology Venting Drilling		o Ecosystem monitoring	Subsidence and seismicity	o Subsidence studies Analysis of regional sensitivity Monitoring studies
		o Studies to predict noise	Fiscal impacts	o Analysis of demand on public service		
				o Study of regional revenue		o Seismic monitoring
	Land-use conflicts	o Forecasts of geothermal development	Effects on cooling tower drift	o Emission and transport studies	Weather modification	o Research survey
		o Characterization of current land-use		o Studies of ecological effects		
		o Analysis of conflicts				

Table 5.14-1 (Continued)

The Geysers-Calistoga KGRA (Cont.)	Landslides and soil erosion	o Study of slope stability and geologic hazards	Economic impacts	o Analysis of economic trends
		o Mapping of faults	Demographic impacts	o Analysis of demographic trends
		o Studies of accelerated soil erosion		o Analysis of the quality of life
		o Study of rock mechanics	Degradation of groundwater and hot springs	o Study of potable groundwater resources
		o Assessment of regional geology		o Study of hot springs
	Rare and endangered species	o Study of rare plants in the region		
		o Study of peregrine falcon habitats		
Mono-Long Valley	Economic development of resource	o Studies to obtain more information on the resource and proposed use	Induced seismicity	o Seismic monitoring studies
				o Emission and transport studies
	Land-use conflicts	o Forecasts of geothermal development	Cooling tower drift	o Studies of ecological effects
		o Analysis of conflicts		
	Air quality protection	o Studies to predict pollution: Source terms; Meteorological measurements; Air quality monitors	Demographic changes	o Analysis of demographic trends and quality of life
	Water quality and supply	o Study of waste disposal and water requirements		

Table 5.14-1 (Continued)

Mono-Long Valley (Cont.)	Natural ecosystem	o Collection of baseline data and identification of rare and endangered species				
	Protection of hot springs	o Hydrology studies				
	Archaeological and cultural concerns	o Appropriate surveys and mitigating measures				
Coso Hot Springs	Air quality	o Studies to predict air quality degradation: Emission measurements Meteorology Air quality monitors	Ecosystem quality	o Collection of baseline data o Ecosystem monitoring	Induced seismicity	o Seismic monitoring studies
			Water quality	o Study of waste disposal and water requirements		
	Archaeology and cultural concern	o Appropriate surveys and mitigating measures	Land surface movement	o Assessment of regional geology		
	Fault zone identification	o Regional geological studies	Injection of geothermal fluid	o Assessment of regional geology		
	Protection of hot springs	o Study hydrology of the hot springs				

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Lowcu Miller, DOE San Francisco Operations Office, Division of Environment and Safety, August 1979.

* The Imperial Valley Environmental Project addressed all of the following issues (and more) with one exception--cooling tower drift.

the need for continuing DOE involvement in the region, and the form which that involvement will take, have not been assessed. A mechanism that would provide coordination and follow-up after the preliminary assessment phase needs to be developed if the overview approach is to be fully utilized.

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6. Lowell Miller, DOE San Francisco Operations Office, Division of Environment and Safety, August 1979: communication.

5.2 OVERVIEW OF STATE AND LOCAL GOVERNMENT INITIATIVES

Over a dozen state agencies now exercise authority over various aspects of geothermal regulation. As geothermal energy has emerged as an environmentally preferred energy source for electric power generation, significant efforts have been made to rationalize this regulatory framework as a means to expedite development. The state's activities have expanded to include information dissemination, environmental research, development, and demonstration of direct applications.

An important geothermal policy issue in California is the impact of geothermal development on communities. Local communities must manage both the direct and indirect effects of particular projects. The state (and the federal government) has therefore attempted to enhance local roles in the projects. There has been a two-fold transfer of expertise and authority from the state to county governments. State agencies are delivering information and expertise to local bodies to enable them to understand and plan for the effects of geothermal development. Once the capabilities are in place, provision has been made for comparable transfer of authority over the development and operation of both direct and electrical applications of geothermal resources.

This section summarizes the activities of state and local organizations:

Section 5.21 lists the twelve state agencies most directly involved in geothermal energy activities, and describes their roles. Efforts among state agencies to coordinate, consolidate, and streamline permitting and regulatory activities are described. Activities to increase coordination and the flow of information to federal and local bodies are also reviewed.

Section 5.22 presents the principal state-level regulatory programs of the Public Utilities Commission (PUC) and the Energy Commission (CEC). Recent legislation providing for the delegation of some of these powers to qualified county governments is also discussed.

Section 5.23 describes state-sponsored commercialization activities. A list of source documents is first presented, which can be used to trace the development and status of geothermal activities in the state. Five generic issues which could potentially block geothermal development at a given site are discussed, along with examples of state efforts to reduce their impact. The remainder of the section describes the present status of commercialization activities at The Geysers-Calistoga, the Imperial Valley, and in other geothermal resource areas.

Section 5.24 describes local activities in the Imperial Valley and The Geysers-Calistoga regions. These include data collection, efforts to coordinate the activities of local government bodies within the region (ranging from informal contacts to Joint Powers Agencies), and regulatory programs. The difference between the two regions are highlighted, along with the accompanying differences in local priorities.

5.21 INSTITUTIONAL ASPECTS OF GEOTHERMAL DEVELOPMENT

The expansion of interest in geothermal energy has brought about the involvement of a number of government agencies. Overlapping legal responsibilities have been created, producing duplicative and often conflicting requirements for would-be developers. During the past several years, state and federal officials have attempted to forge an efficient and coherent governmental framework to encourage and oversee geothermal activities in California. This section sketches the present activities and responsibilities of local and state agencies. It also summarizes some current proposals for further institutional development.

STATE LEVEL COORDINATION

Prior to 1976, attempts to coordinate state involvement in geothermal energy were limited to exchanges of information among agencies. In 1976, the California Legislature created a state Geothermal Task Force to identify informational, economic, and regulatory actions which could expedite geothermal development in the state.* The Task Force identified a number of information gaps for which government-supported research was deemed necessary. It also recommended a number of regulatory and economic initiatives to support geothermal development.[1]

The Geothermal Resources Board (GRB) was established in 1971 as an independent body within the state Resources Agency, with membership including the heads of the state regulatory agencies involved with geothermal energy. The primary function of the GRB is regulatory. It is chartered to oversee state agency activities which affect geothermal energy (e.g., by the Division of Oil and Gas or the Division of Mines and Geology). However, the GRB has also provided a forum for exchange of information, especially through its Technical Advisory Committee (TAC).

The GRB conducted a series of workshops in the winter of 1978-79, under a grant from DOE. The workshops brought together representatives from government, industry, and the public. The workshop report, Significant Problems in Geothermal Development in California, updated the issues raised by the State Geothermal Task Force.[2] This and other activities have yielded a series of formal and informal agreements among local, state, and federal agencies streamlining and expediting geothermal regulation.

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* AB 3590 (Kapiloff). See Appendix II for a summary of California legislation relevant to geothermal development.

The membership of the Technical Advisory Committee consisted of staff personnel from state agencies, plus local government officials and representatives of industry and public interest groups. TAC evolved into the principal forum for exchange among state agencies. A number of subcommittees worked independently to analyze actions by government and private groups, and to develop policy recommendations for represented agencies. In particular, the Policy Subcommittee reviewed proposed program actions submitted by the various state agencies for effectiveness and consistency; and the Land Use Subcommittee monitored state and federal leasing activities.

High priority has been given to the consolidation of environmental review and permitting, in which a lead agency is designated to coordinate administrative functions.* This consolidation reduces the time and costs to both developers and government by eliminating overlaps and inconsistencies. Consolidation has taken place for at least one geothermal project: CEC is the lead agency for preparation of the environmental documents for a proposed plant at The Geysers.** At this stage, each consolidation will require a Memorandum of Understanding (MOU) among the agencies involved, delineating their respective duties.

A state <u>Geothermal Coordinating Committee (GCC)</u> was created in the fall of 1979 to formalize the coordinating and information exchange roles of TAC. A MOU was circulated in August to twelve state agencies involved in geothermal energy regulation (see below);[3] as of January 1980, nine have signed the MOU.*** The committee consists of one member from each signatory agency, plus three public members to be selected by the governmental representatives. TAC has now reverted to its nominal role as technical advisory body to the GRB.

The twelve agencies all have either an interest in or some responsibility for geothermal energy in California:

<u>Air Resources Board</u> (ARB)

The ARB has general responsibility for air quality within the state. Regulatory decisions by the ARB and

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* This was one of the workshop recommendations. See reference 2.

** This is the NCPA/Shell project. See reference 2.

*** The other three (CEC, DOC, and DFG) are participating in GCC activities, while negotiating amendments to the terms of the MOU.

county-level Air Pollution Control Districts will determine the abatement measures required at geothermal facilities.

California Energy Commission (CEC)

The CEC has by far the largest direct role in geothermal energy development. Siting approval for all facilities over 50 MWe must be obtained from the CEC.* The CEC also has been the most active state proponent of geothermal development through grants, technical support for county planning, channeling and coordination of information flows to developers and local governments, and lobbying before federal agencies and legislators for more federal support.**

Department of Conservation (DOC)

The DOC is responsible for much of the resource exploration and assessment activities and some regulation through its Division of Oil and Gas (DOG) and Division of Mines and Geology (DMG).

DOG has been designated by AB 2644 as the lead agency for assuring that geothermal energy projects comply with the California Environmental Quality Act (CEQA).*** It has published a set of regulations describing the procedures developers must follow for an Environmental Impact Report.[4]

DOG also collects bonds posted by drillers of wells to ensure adequate funds for cleanup or closing of wells. Under AB 3707, the bonds required of low temperature geothermal drillers have been reduced.[5]

DMG is working with both the Department of Energy and the U.S. Geological Survey to assess low and moderate temperature resources under the State-Coupled Program. Phase I activities during 1979 centered on gathering hydrologic data for compilation to produce a map of geothermal resources for public use.+ Cursory studies of the Central Coast Range, the Mono Basin, and the Chula Vista area of southern San Diego County were also completed. In addition, bottom hole temperature data were collected at the Huntington Beach Oil Field.[6]

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* See Section 5.22.2 for a discussion of CEC regulatory powers and programs.

** See Section 5.23.

*** See Sections 5.22 (b) and 5.23 for more discussion of AB 2644, and Appendix 4 for a full citation.

+ Reported at TAC meeting September 11, 1979.

Department of Fish and Game (DFG)

DFG has general authority over fish and wildlife protection, and habitat and stream flow preservation. DFG has direct authority over a geothermal project if it alters streambeds or crosses the high water mark of a stream.[7]

Department of Health Services: Environmental Health Services Branch (DHS)

DHS issues permits for facilities which handle or process hazardous substances. A number of geothermal wastes may be included under these programs.[1]

Department of Parks and Recreation: Office of Historic Preservation (OHP)

This office is concerned with geothermal developments only as they may affect historic sites.

Department of Water Resources (DWR)

DWR supplies power to the State Water Project. The agency plans to operate geothermal power plants at The Geysers and in the Imperial Valley.*

Office of Planning and Research (OPR)

OPR has developed a set of guidelines for preparation of Geothermal Elements to County General Plans with assistance from the Office of Permit Assistance.[8] Adoption of an acceptable Geothermal Element entitles a county to apply for delegation of CEQA powers and power plant siting authority.**

OPR also operates a clearinghouse of geothermal project Environmental Project Reports, and provides a forum for resolution of any disputes over lead agency status under the California Environmental Quality Act.[9]

Public Utilities Commission (PUC)

The PUC retains responsibility for permitting geothermal power plants, and for establishing rate structures for geothermal electricity, and perhaps over direct use as well. (See Section 5.22 for more details)

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* See Sections 2.2 and 4.22.

** This option was created by AB 2644. See Section 5.24 for more details.

Solid Waste Management Board (SWMB)

The SWMB issues permits for surface discharges and drilling dumps, and monitors compliance with county Solid Waste Management Plans. For geothermal operations, the SWMB has delegated this function to the Water Resources Control Board.

State Lands Commission (SLC)

The SLC has jurisdiction over all state-owned lands.[1] Where geothermal resources underly such lands, SLC is directly involved in planning for development, making trade-offs with other possible uses. SLC also administers leasing of state lands for geothermal development.

Water Resources Control Board (WRCB)

The state WRCB and nine regional boards administer state and federal programs for preventing hazardous discharge into surface and subsurface waters. The WRCB has cooperated with the DOG in administering geothermally related discharges.[1]

Relations with the Federal Government

A major theme of state activities has been coordination with federal activities and the design of complementary state programs. A conscious effort has been made to structure the state program to fill gaps in federal activities, and to promote federal support of programs to which the state has assigned high priority. This includes using state dollars to co-fund projects with federal agencies. (See discussion below in Section 5.23.) In addition, federal representatives were invited to participate at TAC meetings, some of which were devoted entirely to federal-state relations.[9] TAC members have also cooperated in efforts to alert their agencies to proposed federal actions and to organize lobbying efforts. These functions will be continued by the Geothermal Coordinating Council.

State-Local Relations

In California, local government entities have great influence over geothermal energy development. The tradition of home rule includes local control over most planning and land use functions. The state has chosen to retain this traditional pattern for geothermal activities. In addition, the site-specific nature of geothermal energy has encouraged reliance on the special knowledge of local county governments and regional air and water boards. AB 2644 makes authority over CEQA compliance and power plant siting potentially available to county government.*

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* See Section 5.24 and 2.2 for site-specific details of activities.

An important issue confronting local communities is whether they have the evaluative and technical resources necessary to effectively direct geothermal development. The state and federal governments have provided financial assistance and staff to counties for planning purposes. For example, the CEC provided technical assistance to the development of a Geothermal Element to the Imperial County General Plan. CEC and the federal BLM have helped finance monitoring of meteorological conditions in The Geysers region by the Lake County Air Pollution Control District, which uses the data in permitting decisions.*

In some cases, several counties are directly affected by a single geothermal development. Under these circumstances the creation of organizations to coordinate county involvement has been encouraged. The most active to date has been the GRIPS Commission (Geothermal Resources Impact Study), composed of Napa, Sonoma, Mendocino, and Lake Counties, which covers the Geysers region.** GRIPS has worked with the CEC to gather regional environmental data and identify critical information gaps.

Several state agencies have continuing programs to improve information flow and skills transfer to counties. One of the GRB workshops dealt specifically with "County Planning for Geothermal Development," and was attended by county planners and supervisors from throughout the state.[2] The Office of Planning and Research has drafted a set of guidelines for counties to use in preparing a geothermal element for their general plans.[8] The 1979 CEC geothermal research and development budget includes an "Intergovernmental Coordination and Institutional Barrier Analysis" element which is designed continue assistance to counties and other local agencies at present centers of activity, and in areas of potential development.***

The recent increase in interest for direct use of low and moderate temperature resources will strengthen local involvement. A number of communities are becoming involved in planning and development of direct appropriations to provide community economic development. The city of Susanville

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* See provisions of the Geothermal Resources Development Account under the update on State Activities in Section 7.3 below.

** See reference 10 at 4 - 8, for a discussion of the GRIPS Commission and its activities.

*** Beginning in 1980, CEC will administer 30% of paybacks from BLM leasing revenues as grants to localities with geothermal resources. See update on the Geothermal Resource Development Account, Section 7.3 below.

is working on a geothermal district heating project, with state and federal assistance. Following a somewhat different approach, the city of Desert Hot Springs is considering the establishment of a geothermal-heated industrial park, after a resource assessment was made with state assistance. The city of El Centro is preparing to install a geothermally-powered space conditioning system in its Community Center, with assistance from DOE. All these efforts are considered prototypes for other local governments within the state. Their success should provide further impetus to such development.

REFERENCES

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3. State of California, Memorandum of Understanding Creating a State Geothermal Coordinating Council, Unpublished, transmitted to signatories August 29, 1979.

4. California Administrative Code, Title 14, Division 2, Chapter 2. Implementation of the California Environmental Quality Act of 1970. Published in late 1979.

5. Assembly Bill 3707 (Chapter 1270, Statutes of 1978).

6 Roger Martin, California Division of Mines and Geology, California Low and Moderate Geothermal Resource Assessment Program, presented at the Resource Assessment Commercialization Planning Meeting, Salt Lake City, Utah, January 21-24, 1980.

7. Science Application, Inc., Total Use Scenarios for Imperial Valley Projects, Review Draft, La Jolla, California, December 1978. Prepared for U.S. Department of Energy.

8. State of California, Office of Planning and Research, General Plan Guidelines, Draft, unpublished, April 10, 1979.

9. State of California, Geothermal Resources Board, Summary: Federal-State Technical Advisory Committee Meeting of the Geothermal Resources Board, December 6, 1978 (unpublished).

10. State of California, Energy Commission, Exploring New Energy Choices for California, 1979/80 Report to the Legislature, Draft, Sacramento, May 1979.

5.22 REGULATORY ASPECTS

Regulation and permitting of geothermal development is essentially a three-phase process. The first phase involves leasing and exploration activities. The second phase includes siting and construction of power plants and related transmission facilities. Operation of the completed facilities in a manner consistent with public health, with reasonable cost and reliability, adds a third phase.

Government actions required during the first phase include: (1) an environmental report; (2) a city or county use permit; (3) a Regional Water Quality Control Board waste discharge permit for a drilling sump; (4) a solid waste management permit for a drilling sump; (5) a Department of Health permit for a drilling sump; (6) a Division of Oil and Gas permit to drill a well; (7) a permit from the Air Pollution Control District authority to construct and a permit to operate. If the proposed project is on Federal lands, the operator must also obtain permits from the U.S. Geological Survey or the Bureau of Land Management. The permitting processes for exploration and development on public lands is reviewed in Section 2.21 above.

Milestones for the power plant siting and construction and operation phases include (1) an environmental report (for both the California Environmental Quality Act and the National Environmental Policy Act); (2) Approval of a Notice of Intent and an Application for Certification from the California Energy Commission;* (3) a certificate of Public Convenience and Necessity from the Public Utilities Commission (if investor owned); (4) a water discharge requirement permit from the Regional Water Quality Control Board, and (5) authorization to construct and a permit to operate from the local Air Pollution Control District.

The regulatory concerns and activities of the Public Utilities Commission and the California Energy Commission relevant to geothermal development are discussed below.

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* The NOI step is eliminated for power plants located on a proven resource (see Section 5.22.2).

5.22.1 PUBLIC UTILITIES COMMISSION

The California Public Utilities Commission (PUC) was created by the state to protect its residents from abuses of monopoly power and destructive competition. Because the costs to consumers could be reduced by merging competitors within a geographical area, the state has permitted the existence of service monopolies, such as electric and gas distribution, under the scrutiny of the PUC.* The PUC has been given broad powers to investigate and analyze the internal operations of companies falling under their jurisdiction.[1]

The major impact of PUC activities on geothermal development comes from its treatment of investments in rate determination, allowance of expenses, and the establishment of return on investment. The commission's authority to potentially restrict entry into certain business activities and the threat of public scrutiny also create uncertainty for the developer. These considerations affect direct-use applications and electrical generation somewhat differently, and so are discussed separately below.

ELECTRICITY GENERATION

The major involvement of the PUC in geothermal electrical generation is rate regulation. The commission is expected to hold rates at the lowest level which allows the utility a just and reasonable return on its investment.[2] In determining appropriate rates for a company the commission must approve their rate base** and operating expenses,+ and then determine an allowable return on their investment.

Several issues arise because electricity generation from geothermal energy is a new technology. The risks are complex++ and treatment for those risks are uncertain under

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* Regulation of electricity and natural gas has been patterned after that of railroads because these industries lend themselves to natural monopolies. Inherent factors, such as acquisition of rights of ways, requirement of large capital investments, favored larger firms.

** The rate base is essentially a valuation of the capital investment for the time it is in public use,[3] and is important because it is the basis for determining rates.

+ Operating expenses are costs incurred by the utility which are not capitalized, such as salaries, maintenance and fuel costs.

++ See Section 4.21.

utilities must consider is how their investment will be treated in the event of total plant or reservoir failure. The Commission will allow only the costs they deem reasonable. Another issue is fuel cost, i.e. the price of steam and hot water. If steam or electricity is bought directly from a producer, the utility must justify to the Commission that the price paid is reasonable. At The Geysers, the price allowed is an average of the other fuel costs incurred by the utility. The cost structure for hot water hydrothermal purchases will have a significant impact on future development in the Imperial Valley.

In general, the PUC attempts to allow a return on equity commensurate with other private companies in similar risk groups, but this may be difficult to determine for new hydrothermal electric power plants. "The fair rate of return" is normally set by the regulatory commission on the basis of a weighted average of the actual interest cost of debt instruments, and prevailing market rate for equity for companies with similar risk characteristics.[3] This is by no means a precise process. The commission is not bound to any specific formula for rate determination and must rely heavily on judgement.[5] Utilities have typically been allowed rather low returns, and thus are discouraged from risk taking. The commission is currently empowered to grant geothermal investments a rate of return one and one-half percent above that normally allowed.[5] In addition, the PUC has expressed an intention to provide rate-of-return incentives for the use of alternative energy sources.[6] However, the effect on utility choice of fuel sources may be limited without specific legislation.

The California Public Utilities Code requires that any utility must have a Certificate of Public Necessity and Convenience before it can operate within the state.[7] This requirement may create a number of uncertainties for new entities interested in producing geothermal electricity. They may be denied a permit, thus preventing them from entering the market, or if their operations fall under those outlined in the code as the functions of a utility they may be required to go through the time-consuming process of obtaining a certificate. Since the definition of a utility may be crucial, the applicable criteria are discussed briefly below.

The first requirement for utility designation is that the type of business be among those so defined by the state. The California Constitution specifically includes as public utilities any private corporation, individual, or association involved in the production, generation, transmission, delivery or furnishing of heat, light or water power.[8] Electricity generated from geothermal resources, if intended for public use, would be covered by statutes.

The "public use" requirement* is applied to differentiate those businesses that offer services not available to the public from those which are intended for public use. Such services need not be directly delivered to the public. Private corporations or individuals providing services to existing public utilities might also be declared utilities.[9] Entities selling electricity to a utility for resale to the public might also be considered a utility for regulatory purposes.

Meeting the statutory requirements for a certificate of public convenience and necessity may prove onerous to developers or new entities interested in producing geothermal electricity.

If an organization desires utility status, they must apply to the PUC. The commission will review the case and then can deny the request or grant it fully or in part.[10] Because one purpose of certification is to limit services of a similar and competing nature, the applicant must show cause for approval. Successful challenge of the necessity of the new service by an existing utility could mean that certification would be denied. Any challenge can entail a lengthy legal process and such uncertainty has discouraged developers from direct sales of electricity to the consumer.

Alternatively, an entity which did not seek utility status may find itself brought under PUC regulation against its wishes. For presently unregulated organizations, the disadvantages of being regulated as a public utility is twofold. First, the rate of return allowed to a regulated company is typically far below that earned by an unregulated one. For many companies the risk of being subjected to a lower return is unaccceptable and discourages them from being involved with the industry.

Second, utility regulation brings a great deal of public scrutiny. The PUC is empowered to inspect the accounts, books, documents and papers of any public utility, and to question under oath any utility officer, agent or employee regarding their business activities and affairs.[11] Much of this information will subsequently become public knowledge. While this will not pose an additional burden to existing utilities, the burden of having internal operations overseen by a utility commission may dampen the interest of organizations not currently under public regulation.

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*There are exemptions for public-oriented organizations that typically would come under utility definitions but are not thought to need the control of PUC regulation. In California, these include municipal utilities and irrigation districts. See Reference 8.

At this time it is unclear how the PUC will look upon developer-produced electricity and its subsequent sale to a utility. Both the federal and state governments have funded studies of relevant policy considerations for the purpose of drafting appropriate regulations.

DIRECT USE APPLICATIONS

Market entry and the problems associated with obtaining the necessary certification for direct-use projects will depend on the classification of the geothermal application involved. Some companies expecting to provide very limited services may not be aware that they could be subject to regulation. However, the acquisition of proper governmental approval should precede any significant investment in equipment or construction.

California public utility statutes specifically include pipeline, water, and heat corporations as entities subject to regulation when supplying services to the public.*[1,2] The transmission and distribution of geothermal heat to multiple users for direct uses is expected to be subjected to public utility regulation if the service is dedicated to public use. California courts have stated that "dedication" is normally evidenced by some act which indicates a willingness to provide service on equal terms to all who apply.[2,13,14] Although regulation in a specific case will depend on the circumstances involved, existing cases suggest that a geothermal supplier could structure arrangements with industrial, commercial, or even residential users based upon negotiated supply contracts without becoming subjected to public utilities regulation.

Rate regulation of direct-use applications will generally follow the pattern outline in the preceding discussion on geothermal electricity generation. It is difficult to evaluate at present because of the lack of historical cost and performance information.

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*Water systems require certificates of convenience and necessity; heat or pipeline corporations may not.

REFERENCES

1. 41 California Jurisprudence 2nd, Section 23.

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3. Public Utilities Commission Section, California Blue Book, 1975.

4. 41 California Jurisprudence 2nd, Section 2.

5. 41 California Jurisprudence 2nd, Section 64.

6. California Public Utility Code, Section 454(a).

7. California Public Utility Code, Section 1001.

8. 41 California Jurisprudence 2nd, Section 5.

9. 41 California Jurisprudence 2nd, Section 99.

10. 41 California Jurisprudence 2nd, Section 13.

11. California Public Utility Code, Section 314.

12. California Public Utility Code, Section 261(a).

13. J. Nimmons, State by State Analysis of Public Utility Laws Affecting Geothermal Direct Heat Applications, The Earl Warren Legal Institute, Berkeley, California.

14. State Public Utility Regulation of Geothermal Direct Heat Suppliers, Earl Warren Legal Institute, University of California, Berkeley. Proceedings of The Third Annual Geothermal Resources Council Conference. September 3, 1979.

5.22.2 CALIFORNIA ENERGY COMMISSION REGULATIONS AND POWER PLANT SITING

The California Energy Commisssion (CEC) was created by the legislature in 1974, through passage of AB 1575 ("the Warren-Alquist Act").[1] It has lead responsibility for energy planning and the siting of electricity generation plants of 50 MWe or greater. The siting of geothermal electric plants has been included under this mandate in the past; recent legislative changes have modified the jurisdiction of the CEC somewhat (see below). This section summarizes the CEC regulatory and siting process as it applies to geothermal facilities.

ENERGY PLANNING

The CEC is responsible for developing supply and demand plans for the state, working from utility submissions and staff work.[1] The current plan predicts relatively slow growth in energy demand, and a rapid increase in the proportion supplied from geothermal sources.* This plan is the basis against which utilities must justify proposed power plants. The planning process has helped to clarify the expectations for geothermal energy, by identifying it as a relatively important element in the state's future electricity supply mix.

POWER PLANT SITING: THE NOI/AFC PROCESS

Under the Warren-Alquist Act, the CEC has exclusive authority over certification of power plant siting;[1] since the Goggin bill of 1978, (AB 2644) plants producing less than 50 MWe are exempt.** The siting process has two phases designed to illuminate all important generic and site-specific considerations.[2]

The Geothermal Siting Process

Geothermal power plants have always received preferential treatment in CEC siting actions, motivated by the special nature of the resource.+ Even under the original

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* See Section 3.

** See Appendix 2.

+ The normal power plant siting process is more complex and lengthy. Utilities must submit three alternative sites with the NOI. The CEC is given 12 months to rule on the NOI, following conceptual analysis of generic issues. The AFC process may take up to 18 months during which the project is analyzed in detail. CEC has been mandated by CEQA to mitigate adverse environmental impacts.

Warren-Alquist Act, no alternative sites were required when submitting a NOI for a geothermal facility.*

AB 2644 greatly expanded these preferences. AB 2644 eliminated the NOI step for geothermal power plants located on a proven resource. It also reduced the maximum time for the AFC process to 12 months. The full CEC site approval process is therefore reduced to no more than one year, from two and one half years for conventional power plants.

The most sweeping changes contained in AB 2644 have yet to be realized. The bill provides that a county may gain complete control over the siting of geothermal facilities. The key to this new regime is the development of a Geothermal Element in county General Plans. The element must contain a plan for geothermal development in the county, including provisions for environmental and social impacts.

If a county's Geothermal Element is "acceptable," CEC is empowered to approve a county-level certification program to supercede the present NOI/AFC process.** To be acceptable, the program will have to include a 12-month processing maximum and public hearings. The CEC will retain appellate powers over substantive issues, and will be required to review the county's operation of its program. AB 2644 has been the biggest effort yet to streamline and expedite the regulatory process for geothermal power. Other provisions of the bill reduced the numbers of permits required from other state agencies. It also provided that a county with an approved geothermal element can be delegated the lead agency role for assuring compliance with CEQA requirements by DOG.

As of September 1979, no counties have applied for the siting or CEQA powers. Imperial County is the only county with a geothermal element, and has made no move to request certification for delegation because it deems the public hearing and application processing requirements too substantial and costly for the community to bear. Lake County is preparing a geothermal element, but it is not yet complete. No other counties have embarked on the preparation of a geothermal element, so the CEC will remain the controlling agency for siting.

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* See Appendix 2; the exemption is stated in Public Resources Code Section 25540.

** See Appendix 2; Public Resources Code, Section 25540.5.

REFERENCES

1. Assembly Bill 1575 (Chapter 276, Statutes of 1974), codified as Section 25000, et. seq., Division 15, California Public Resources Code.

2. State of California, Energy Commission, Power Plant Siting Policy Paper, Sacramento, California, November 1978.

3. Chuck Hall, Lawrence Livermore Laboratory, September 7, 1979: communication.

5.23 STATE-SPONSORED COMMERCIALIZATION ACTIVITIES

INTRODUCTION

Geothermal energy has been assigned an important role in California's Alternative Energy and Transportation Program.[1] State efforts to maximize geothermal electric and direct heat applications are tailored to complement federal and local government efforts and private initiatives. The highest priorities are assigned to activities which can be effectively pursued within the state's budgetary and personnel limits. This strategy involves specific actions at individual sites, and statewide efforts to improve the economic and regulatory climate.

This section describes state priorities for the commercialization of geothermal energy resources. Five generic barriers to commercialization are described, along with examples of state efforts to overcome them. A more detailed description of site-specific activities follows, divided into three sections; The Geysers-Calistoga; Imperial Valley; and other geothermal areas.

A major theme of state commercialization initiatives has been the removal of institutional barriers. Considerable effort has been expended to streamline the regulatory requirements faced by geothermal developers, and to delegate this consolidated authority to county governments. Many activities have therefore involved the identification and elimination of duplicative or conflicting regulatory requirements. Others have generated baseline data (geologic, technical, and environmental) to assist planning and regulatory bodies. A third type of action has been to transfer to county and regional bodies the skills and staff resources necessary to use the information to plan and regulate.

The mix of state commercialization activities differs somewhat between electrical and direct use (non-electrical) applications. (See Table 5.23-1, State Programs for Commercialization of Hydrothermal Resources, 1976-1980.) Electrical applications have long been the primary focus of private sector activity. State commercialization activities therefore centered around the elimination of second generation problems which would impede development. The assessment and mitigation of environmental impacts associated with development had a high priority. The state has been active in cofunding of research, development, and demonstration activities because of the urgent need to resolve the complex technological problems associated with electricity generation from liquid-dominated resources. State agencies have also supported the efforts of these programs to seek additional federal funding. Finally, regulatory processes were streamlined to expedite development.

Table 5.23-1. State Programs for Commercialization of Hydrothermal Resources in California 1976-1980.

PROGRAM PHASE	AGENCY/ PROGRAM	START DATE	PROGRAM DESCRIPTION	PROGRAM APPLICATION			GEOTHERMAL AREA			
				Direct	Elect.	Co-gen.	State-wide	The Geysers	Imperial Valley	Other
RESOURCE ASSESSMENT	CEC	1977	Mapping of Geothermal Resource Area, Susanville, CA.	●	●					(S)
	Caltrans	1978	Feasibility Study using geothermal energy for proposed highway maintenance station, Bridgeport, CA.	●						(L)
	DMG	1979	Mapping Geothermal Resources, Calistoga, CA.	●	●			●		
	DMG	1979	Study of Low Temperature Geothermal Reservoir, Paso Robles, CA.	●						(P)
	DOG	1980	Study of Low Temperature Geothermal Resources, Big Valley, CA area.	●				●		
	DOG	1980	Geothermal Fluid Reservoir Assessment, The Geysers.	●	●			●		
	DOG/DMG	1980	Study of groundwater regime to protect fresh water acquifers from improper geo-thermal fluid disposal, Calistoga, CA.	●	●			●		
	DOG	1980	Gravity survey of geothermal resources, Desert Hot Springs, CA.	●	●					(R)
TECHNOLOGY ASSESSMENT	CEC/DOG	1976	Collection of baseline data about possible subsidence from withdrawal of hot water.	●	●				●	
	CEC/Imperial County	1977	Evaluate studies of cooling water availability.		●				●	
	CEC	1977	Administer DOE-funded study of the economics of direct heat applications in Lassen and Modoc Counties.	●						(S)
	CEC	1979	The Geysers hot water applications: co-generation and direct uses.	●		●		●		
	CEC/DOE/ GRIPS	1979	Preparation of a regional environmental and sociological data base.	●	●			●		

Table 5.23-1. State Programs for Commercialization of Hydrothermal Resources in California 1976-1980.

PROGRAM PHASE	AGENCY/ PROGRAM	START DATE	PROGRAM DESCRIPTION	PROGRAM APPLICATION Direct	Elect.	Co-gen.	GEOTHERMAL AREA State-wide	The Geysers	Imperial Valley	Other
RESEARCH, DEVELOPMENT & DEMONSTRATION	CEC/Lake Co. APCD	1978	H_2S monitoring: maintenance of Air Quality Monitoring Stations.		●			●		
	CEC/DOE	1978	o Space-heating and snow-melting demonstration	●						(M)
			o Development of district heating plan	●						(M)
	DWR/private corp. joint venture	1979	Feasibility study on design of a 55-MWe cogeneration power plant using geothermal heat to dry and pre-heat wood waste.			●				(W)
	CEC	1979	Support demonstration of a binary conversion system at East Mesa, Brawley, and Heber.		●				●	
COMMERCIALIZATION	CEC	1976	Organize Imperial Valley Planning Project Committee to identify priority planning needs.	●	●				●	
	CEC	1978	Promote additional federal funding of direct-use demonstrations.	●			●		●	
	TAC/GCC	1978	Promote interagency coordination for transmission line routing, water use planning, environmental impacts management, and processing of permit applications.	●					●	
	CEC/DOE	1979	State agencies are active through the State Coso Advisory Committee.	●						(C)
	CEC/Imperial County	1979	Provide assistance to Imperial County planners for preparation of Geothermal Energy element to General Plan.	●					●	

Source: Division of Mines and Geology, "Geothermal Resources of California", California Geologic Data Map Series #4, California Department of Conservation, 1980.

L E G E N D

C	Coso	MB	Mono Basin	S	Susanville
L	Lassen County	P	Paso Robles	SL	San Luis Obispo Co.
M	Mammoth Lakes	R	Riverside County	W	Wendel-Amadee

Direct-use activities are less advanced, so more state emphasis has been placed on resource and market identification. The state is actively involved in geothermal resource assessments - such as the Division of Mines and Geology's project with DOE to identify warm water locations throughout California. Efforts are also underway to increase knowledge of potential markets by analyses of potential uses and projections of market penetration of geothermal direct-use applications. Elimination of duplicative and conflicting regulations also received attention. The State Lands Commission (SLC) has recently surveyed all regulations affecting direct use; and a study of regulations applicable to drilling of low temperature geothermal wells is underway.*

The documents listed below chronicle the development and status of state priorities. The earliest contain summaries of geothermal knowledge and activities at the beginning of the present period of heightened interest in geothermal applications, and identify the first sets of informational and institutional needs. Subsequent volumes detail the expansion of activity, and the resolution of successive layers of constraints. These documents provide a convenient history of California state actions, and have been relied upon heavily in the discussion that follows.

1976:

Geothermal Energy Resources in California: Status Report.[2] Summarizes knowledge of and activities at California's geothermal resources, plans then existing for their development, the regulatory framework, and R&D activities planned or underway.

1977:

Biennial Report of the State Energy Commission, California Energy Trends and Choices, Volume 5: Status of Alternative Energy Technologies.[3] Outlines state activities through 1977 in geothermal and other non-conventional energy technologies, and proposes future programs.

Jet Propulsion Laboratory, California Institute of Technology, Analysis of Requirements of Accelerating the Development of Geothermal Energy Resources in California, JPL 77-63,1977. Summarizes generic and regional issues capable of inhibiting geothermal development, and proposes activities to overcome their impacts.

Stanford Research Institute, Environmental Analysis for Geothermal Development in The Geysers Region. Executive

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* Conversation with Don Hoagland, State Lands Commission, September 27, 1979.

Summary, volume 1-3, May 1977. Identifies possible environmental problems.

Stanford Research Institute, Economic Analysis of Geothermal Development in California, volumes 1-2, May 1977.

VTN-CSL, Economic Study of Low Temperature Geothermal Energy in Lassen and Modoc Counties, California, April 1977. Preliminary study of resource and market potential.

1978:

Report of the State Geothermal Resources Task Force.[4] Presents recommendations for resolving questions about resource and technology availability, environmental considerations, regulatory issues, and the economics of geothermal development.

California Energy Commission, Geothermal Policy Report: Recommendations for a Geothermal Resource Development and Power Plant Siting Policy, adopted March 22, 1978. Recommends specific changes in CEC, procedures, and enabling legislation to streamline and expedite the geothermal power plant siting process.

Geothermal Resource Impact Projection Study Commission, GRIPS Plan, July 31, 1978, Napa, Ca. Presents the GRIPS Commission's findings: data on The Geysers area environment, activities and programs to make more information available; and ways to increase public participation in planning and decision making.

City of Desert Hot Springs, Direct Use Applications of Geothermal Resources at Desert Hot Springs, California, June, 1978. Identifies possible use of local geothermal reservoir.

1979:

Significant[5] Problems in Geothermal Development in California. Summarizes problems identified at four workshops held by the state Geothermal Resources Board. Recommended actions to reduce barriers to geothermal development.

Biennial Report of the California[6] Energy Commission, Energy Choices ... Looking Ahead Updated summary of past and projected activities by CEC, including plans for "innovative technologies."

Energy Commission[7], Exploring New Energy Choices for California, Draft. Outlines the present research and development program of the CEC.

COMMERCIALIZATION BARRIERS

Five general types of barriers have received some state attention. The first potential barrier at a given site is the need for basic reservoir data: volume and temperature of the geothermal fluid, depth, geologic conditions, presence of dissolved gases or solids. The Division of Oil and Gas (DOG) and the Division of Mines and Geology of the state Department of Conservation maintain general information about the surface and subsurface geology of the state. The state Energy Commission (CEC) has been active at some sites: CEC sponsored geologic mapping in the Susanville area of Lassen County, which provided useful information about the subsurface structure.

The second barrier is a lack of data about the local environment: plants and animals, air quality, watersheds, land use, etc. This information is needed by planners and regulators to determine the extent and intensity of permissible development, and to design mitigative and protective measures. The state has supported research and monitoring activities at The Geysers and the Imperial Valley for several years, and is moving to provide similar assistance in other areas.

The third barrier is an uncertain market for geothermal energy. For electricity generation, the state has focused on the cost and availability of transmission lines to link with the California grid. The priority activity has been assurance that geothermal producers can "wheel" their electricity through the lines of major utilities even if these utilities are not customers. AB 3707 authorized the Public Utilities Commission (PUC) to require wheeling.*

For direct use of geothermal heat, site-specific analyses of potential markets are necessary. The state, acting alone or in cooperation with DOE, has funded market surveys for several areas.** The purpose of these studies was to match resources and potential applications.

The fourth barrier is a technology upon which developers and customers can rely to convert geothermal energy into a useful form. The broad range of temperature, purity, and flow rates requires the development of novel technologies or configurations at some sites. The state and federal

* Section 7, codified at Pub. Util. Code S 782. See Appendix 2.

** During FY 1979, CEC funded Science Applications, Inc. to survey the market potential for direct use applications in California. This study was scheduled to be completed during the first quarter of FY 1980.

configurations at some sites. The state and federal governments have provided technological and financial assistance to research, development, and demonstration projects. The discussion below highlights activities of the different locations.

The fifth potential barrier to development is institutional. Since intense interest in geothermal energy is a relatively new phenomenon, government and private institutions are sometimes not structured to provide effective assistance or clear, well-reasoned directives. State-supported studies have identified overlapping authorities and duplicative requirements, as well as gaps in needed* information or expertise among different government bodies. The state has made significant efforts to resolve these problems through legislation providing for expedited review and permit procedures for geothermal projects, designation of a single lead agency for each project to consolidate regulatory activities, and delegation of many planning and evaluation activities to county agencies with demonstrated expertise. Development of county expertise has been supported by financial and technical assistance from state and federal agencies.**

RECENT ACTIVITIES

Commercialization activities are now underway in many resource areas in California. The emphasis of early programs has been on electrification following private sector interest, so that efforts have concentrated on the large high-temperature reservoirs at The Geysers and in Imperial County. Activities are now expanding to other locations, supported by several trends. Budget allocations have expanded significantly, allowing government participation at more sites. Increased interest in direct uses has led to at least preliminary studies at locations with small, low temperature reservoirs. The increased flow of information about geothermal energy has prompted more activities. Finally, escalation in the price of conventional energy sources has increased the attractiveness of geothermal applications.

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* See, for instance, reference 5. During FY 1979, CEC sponsored a review of laws and regulations affecting drilling of low/moderate temperature resources by the State Lands Commission.

** See Section 5.21 for a more detailed discussion of institutional arrangements, and Section 5.22 for a synopsis of the state regulatory program.

In the following subsections, developments in The Geysers and Imperial Valley areas are discussed separately because of the broader range of activities. All other geothermal areas are grouped together.

The Geysers-Calistoga

The Geysers reservoir is by far the most utilized and studied of California's geothermal resource areas.* The primary barriers to further development in the dry steam portion of the reservoir are environmental, with hydrogen sulfide (H_2S) emissions being the most critical. The CEC has funded the Lake County Air Pollution Control District to maintain air quality monitoring stations.[7] This both provides an expanded data base and permits the local APCD to develop technical knowledge. Data from these air monitoring stations are used to evaluate the effectiveness of H_2S abatement technologies being tested.

Another innovation in The Geysers region has been the Geothermal Resource Impact Projection Study Commission (GRIPS).** GRIPS is a joint powers agency formed by Napa, Sonoma, Mendocino, and Lake counties in 1978, primarily to develop a regional data base. Grants from the CEC and the DOE have been used to collect a variety of environmental and sociological data. GRIPS also serves as a mediator among public and private organizations involved in geothermal development in the area.

The Geysers also has a very large projected potential for liquid-dominated hydrothermal resources. The resource is hot enough for both electricity and direct uses, but has been neglected to date in favor of the steam resource. Present CEC utility projections indicate that the hot water resources will not be exploited until 1988.[8] However, efforts are now underway to encourage early direct thermal uses of hot water resources. The 1980/81 research and development plan submitted to the legislature by the CEC included funding for a benefit-cost analysis of "cascading" use of hot water.*** The project will study direct heat uses of the geothermal hot water after use in electricity generation has reduced its temperature.

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* See discussion supra Section 2.1 and 4.2.

**See reference 7, at 4-8 for a discussion of GRIPS activities.

*** See Section 2.2.

Imperial Valley

Large-scale geothermal development activities in the Imperial Valley are recent phenomena, and many basic research and development activities are still underway. Present state electricity plans include proposals to generate 516 MWe by 1985 and 966 MWe by 1990.*[6,7] To reach this goal, the state has assigned a high priority to development activities in the valley. Present projects address a variety of the technical, economic and environmental questions now delaying development.

An important focus of state efforts has been support of the demonstration of a binary conversion system at East Mesa, and of the pilot plant at Brawley. Both of these projects are also supported by the U.S. Department of Energy.** The state has also been active with research grants for equipment testing and evaluation and in attempts to renew financial support for a 50 MWe binary demonstration power plant at Heber.***

The state has also initiated a number of activities in support of geothermal commercialization. In FY 1976/77, CEC organized the Imperial Valley Planning Project Committee, including members from federal, state, and local agencies, and from SDG&E, Chevron, and the Electric Power Research Institute (EPRI). The committee identified priority planning needs as transmission corridor planning, provision of cooling water, and understanding of possible subsidence problems.

In 1976-77, the CEC and the DOG co-sponsored a collection of baseline data about possible subsidence from withdrawals of hot water. In 1977-78, the CEC helped the Imperial County planning staff evaluate studies of cooling water availability and assisted in the preparation of a Geothermal Element for the county General Plan. The plan included provisions for controlling water use, preventing subsidence, and planning for transmission facilities. Many of the procedures presented in this Element can be used by other counties in their own geothermal planning processes.

Direct use of geothermal heat is now receiving more attention. One objective of CEC's present research and

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* See Section 4.2, supra, Figure 4.23-1.

** See Section 2.2 for discussion of activities in the Imperial Valley.

*** See further discussion on the demonstration project below, Section 6.2. and Section 7.2.

development plan is to attract additional federal funding for direct use demonstrations in the Imperial Valley.[5]

Finally, the state has attempted to organize interagency cooperation to assist development in the Imperial Valley. It has supported efforts to route transmission lines, plan water use, and develop strategies to handle environmental impacts on a regional basis. A multi-county agreement to form a planning agency similar to the GRIPS Commission (The Geysers region) has been proposed. In addition, state and local agencies have agreed to complete Memoranda of Understanding establishing simultaneous processing of permit applications.[9]

<u>Other Geothermal Resource Areas</u>

As progressively higher priorities are assigned to low temperature and small scale applications of geothermal energy, activities are expanding at other geothermal resource areas in California. Because little has been done in these areas in the past, the first priority at most locations is still the collection of basic reservoir and environmental data. Direct uses of geothermal water for agriculture, aquaculture, industrial processes, and space heating are underway at several sites, and under investigation at several others. These projects are designed to provide basic information which can be generalized to other areas.

- Susanville (Lassen County)

Site studies are relatively advanced. The CEC supported a mapping of the resource area in 1977/78, which produced estimates of the resource.[7] The CEC also administered a federal grant analyzing the economics of direct heat applications in Lassen and Modoc counties.[7] The city of Susanville is now involved in a district heating project with DOG assistance.*

- Wendel-Amedee (Lassen County)

The 1977-78 market analysis by CEC prompted a private developer to start a geothermally heated greenhouse development. The state has provided no direct assistance to this project, but is publicizing it. Several other direct-use projects are in the planning stages, with resource testing underway and possible customers being organized.

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* See Section 2.2 for a listing of the Susanville and Wendel-Amedee projects, and those in other counties.

The California Department of Water Resources (DWR) is working with the same developer to design a 55 MWe cogeneration plant for Wendel-Amedee. The plant would use geothermal heat to dry and pre-heat wood waste before burning. This pre-heating use may be a prototype for economical use of many low-temperature resources.

• Mammoth Lake Village (Mono County)

The CEC and DOE co-funded (80:20) a space heating and snow melting demonstration at a resort development here. Studies of resource and market matches are now underway, aimed at developing a district heating plan in the immediate area.

• Coso (Inyo County)

Coso is considered by some to be the third most promising high-temperature geothermal area in California. However, there has been little opportunity for direct state action, since virtually all the land is within the United States Naval Weapons Test Center. Since 1977, state agencies have been active through the State Coso Advisory Comittee in the planning process, however, assisting the Navy and the Bureau of Land Management (BLM) develop comprehensive plans for their lands. The Naval Weapons Center at China Lake has plans underway to generate electricity from geothermal energy for its own use.[10] A request for geothermal development proposals was issued by the Navy in July 1979, from which a development program will be selected by the end of 1979.* The Bureau of Land Management (BLM) is preparing a leasing program that could open the remainder of the area to geothermal development. The present BLM timetable calls for leasing in 1981.**

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* Personal communication with Tom Dodsen, Naval Weapons Testing Center, September 21, 1979.

** ibid.

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4. State of California, Geothermal Resources Task Force, Report of the State Geothermal Resources Task Force, Sacramento, June 1978.

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6. State of California, Energy Commission, Energy Choices for California - Looking Ahead, Sacramento, March 1979.

7. State of California, Energy Commission, Exploring New Energy Choices for California, The 1979/80 Report to the Legislature, Draft, Sacramento, May 1979.

8. State of California, Energy Commission, FY 80 Program, The Geysers Element, Staff draft, August 3, 1979.

9. State of California, Energy Commission, 1980 Program, Imperial Valley Element, Staff draft, August 3, 1979.

10. State of California, Geothermal Resources Board, Summary: Federal-State Technical Advisory Committee Meeting of the Geothermal Resources Board: December 6, 1978, (unpublished) Pp. 6-7.

5.24 MAJOR LOCAL ACTIVITIES

Local governments play a significant role in geothermal development as managers of the immediate benefits and costs to the community. In counties with relatively large geothermal resources or relatively small existing populations, geothermal development could disrupt existing economic, environmental, and social systems. There is a general policy within the state to support local assessment of the tradeoffs required by geothermal development. Given adequate information and skills, each county can anticipate and direct the effects of geothermal development.

County governments in California now have the opportunity to exercise jurisdiction over most aspects of geothermal energy development. Historically, local governments have exercised their zoning power to control drilling activities incidental to exploration and development of geothermal reservoirs.* In addition, if a county adopts an adequate Geothermal Element to its General Plan (as defined in guidelines set forth by the State Office of Planning and Research), AB 2644 (1978) makes more significant powers available. A county can then apply to the state Division of Oil and Gas (DOG) for lead agency status in assuring compliance with the California Environmental Quality Act with respect to exploratory geothermal wells. It can also apply to the California Energy Commission (CEC) for jurisdiction for siting geothermal power plants.

Technical assistance from both the federal and state governments has been targeted to counties with high priority development potential. In California, Imperial County and The Geysers area counties have received the most attention, and are now better equipped to direct geothermal activities than are other areas of the state.** As development activity proceeds to other areas, assistance by state and federal agencies is expected to expand.***

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* This is limited to lands not under federal control.

** See Sections 5.21 and 5.23 for descriptions of state and federal activities.

*** See provisions of the Geothermal Resources Development Account under update on State Activities in Section 7.3 below.

The rest of this section contains sketches of local government activities in The Geysers-Calistoga and Imperial Valley, two areas that have taken major steps towards preparing for geothermal development. As other geothermal resource areas approach commercialization, other counties will become more actively involved.

IMPERIAL COUNTY: COMMERCIALIZATION ISSUES

Imperial County, the fourth-largest agricultural production county in the nation,* also contains one of the largest known geothermal resources in the world. The critical issue in geothermal development in the county is the search for an accomodation between these two resources. As most of the activity in the county is keyed to agribusiness, geothermal developers must show they can operate with minimal disruption to this dominant activity.

Imperial County has made an extensive effort to determine and balance the actual costs and benefits of geothermal development. In the early 1970's, growing interest in geothermal energy prompted the county to face the potential conflicts with agricultural production. Research funding for comprehensive land use planning was first sought with the state Office of Planning and Research and then with the National Science Foundation RANN (Research Applied to National Needs) Program. Eventually, research conducted by the University of California at Riverside, California Institute of Technology, and the Lawrence Livermore Laboratory contributed to the geothermal element of the county's General Plan.[1]

An extensive public opinion poll and a separate study of leadership attitudes in Imperial County revealed overwhelming support for development, if it included strict environmental controls.[2] The dominant large landowners tended to feel that the economic benefits outweighed environmental costs of geothermal development. Thus, local political forces have not been a barrier to development.

Environmental controls are critical because the economy of the county depends upon a carefully balanced man-made environment. Water from the Colorado River is routed through an elaborate system of canals and distribution and runoff collection channels. Flows are carefully routed to minimize salt build-up. The sensitivity of this capital-intensive network to water and land use patterns dictate the critical concerns in geothermal development in Imperial Valley.[2]

* In 1978, the total agricultural revenue from Imperial County products was $584 million.

Competition for Water Supply

There is currently no long-term policy that successfully addresses this problem. A recent analysis of water availability[3] shows that restructure (i.e., no fresh irrigation water for geothermal coolant uses) will have little effect on overall geothermal development for low and middle growth scenarios. This study forecasts water deficits in two of the four KGRAs under the most restrictive water policies for the high growth scenarios. Current county policy limits fresh irrigation water to the first 75 MWe in each KGRA for a period of 5 years for experimental demonstration plants.* A water policy planning study is proposed in the Geothermal Element.

Seismicity

The actual effect of fluid withdrawal and injection on the seismically active Imperial Valley is unknown. County policy calls for developers to participate with county and state agencies in a monitoring program.

Subsidence

County policy requires injection of geothermal fluids to reduce subsidence, which could severely affect the sensitive slopes of irrigation and drainage systems. Developers are asked to participate with the county in a monitoring program.

The county has been heavily studied in recent years, and a fairly complete data base has been assembled.** With this data, county planners can predict the severity of problems and design mitigating programs.

Current County Activities

Imperial County has engaged in extensive planning for geothermal development throughout the county. The county is aware that it has critical authority over wells on non-federal land. Supported by an extensive environmental data base, it has made a serious effort to develop a scientifically credible General Plan element and to maintain research and monitoring programs where required. The county appears confident that its policy and interests will be respected by state and federal agencies even in decisions over which the

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* See update on recent decision of the California Water Resources Control Board in Section 7.2 below.

** See reference 1 and 2, and Sections 2.2 and 5.12 and 5.23 of this report.

county has no actual jurisdiction.

The Geothermal Element presents a number of policies concerning land use and geothermal development:[2]

- The basic planning tool will be a geothermal overlay zone within which geothermal development will be allowed, subject to a conditional use permit.

- The corollary tool is the conditional use permit incorporating performance standards with which the county can control specific project design features.

- Regulatory costs assignable to geothermal development will be passed on to developers.

- The county generally will seek compensation for environmental degradation rather than injunctions.

- The county will require a generic EIR for each KGRA that can be included by reference in project-specific environmental documentation.

- The county will authorize construction of experimental/demonstration geothermal facilities on state or federal land without zoning actions.

- The county will ensure that its concerns are raised in projects on state and federal lands by holding appropriate hearings.

- The county will cooperate with the CEC and will pursue an active role in CEC regulatory activities in the county.

- The county will establish an office of geothermal development to facilitate development.

- The county will establish an office of monetary policy to match new public service demands with tax revenues from geothermal development.

- The county will participate with the DOG in assuring optimum development of the resource by applying land use control measures.

<u>Future County Activities</u>

Since Imperial County has an "approved" Geothermal Element, it is eligible to apply to the CEC and DOG for delegation of siting and CEQA compliance authority for siting of wells. However, the county has not chosen to do so, apparently because it is concerned over lack of resources to effectively and consistently carry out a regulatory function without outside assistance.* The county is apparently adopting the strategy that its political strength, experience in geothermal resource management, the jurisdiction it does have over wells, and the cooperative policies of state and federal agencies will assure that county policy and interests are respected even in decisions over which the county has no actual jurisdiction.

THE GEYSERS-CALISTOGA REGION

The Geysers-Calistoga region has been the other traditional focus of geothermal activity in California. The geothermal, environmental, social, and political systems are totally different from those in Imperial County. The activities, attitudes, and priorities also differ markedly.

Commercialization Issues

The Geysers resource underlies four counties (Napa, Sonoma, Mendocino, and Lake), but commercial activity in the past has been confined to the dry steam portion of the reservoir in Sonoma County. Development was traditionally paced by the ability of developers to prove supplies for Pacific Gas and Electric (PG&E).[1] Sonoma County has historically favored geothermal development as a revenue-producing activity in a remote part of the county. As the site of the development has grown, environmental problems have commanded more attention. The highest priority is monitoring and abatement of hydrogen sulfide (H_2S) emissions into the air.[4] Secondary attention has been paid to disposal of liquid waste, and to erosion and ecological disruption caused by the facilities.[5]

A more general concern is potential disruption of the present economic and social system by accelerated or continued geothermal development. Napa County is most concerned with preserving the wine industry. Lake and Mendocino Counties have relatively small populations, and their economies are largely dependent upon recreation and tourism. Unlike Imperial County, there is no basic ideological orientation toward growth and development. Hence, geothermal development (especially in Lake County) may be influenced by public anxiety over social and economic disruption. When coupled with general environmental concerns, these fears of the primary and secondary costs of development are critical.

Current County Activities

As described above, development activities in Sonoma

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* Personal communication with Chuck Hall, Lawrence Livermore Laboratory, September 15, 1979.

County have become routine. The county handles requests for geothermal wells and facilities as normal land use activities. The county receives significant revenues from these activities, and considers geothermal development as an important part of its economic base.

Activities in Lake County have been minimal until recently. There are six geothermal power plant projects in process at the present time.* Unlike Sonoma County, there has been considerable controversy over the benefits of geothermal development in Lake County, focusing on issues of potential direct conflict with the recreational and retirement activities that are the mainstays of the present county economy.[6] This has slowed development activities considerably, resulting in a lawsuit by a would-be developer who complained that the present delays and inconsistencies in county permitting are illegal.** It should be noted that timing is an important factor in permit approvals for this general area, since well-drilling, road, and some power plant construction activities are precluded from mid-October through April by heavy seasonal rains.

Neither Napa nor Mendocino counties have accelerated their involvement with geothermal energy. Napa has an approved comprehensive plan for the county but is not encouraging geothermal activity, for fear of conflict with the dominant wine-growing activities. The main concern is over routing of transmission lines from The Geysers to the San Francisco Bay Area.[6] Mendocino County has little experience with geothermal energy, but one deep well is being drilled. The county's general plan was recently declared invalid by the state, and the county is under a complete development moratorium.

The fact that The Geysers-Calistoga geothermal resource includes parts of these four counties has resulted in coordination and information problems. To address these problems, the counties formed the Geothermal Resource Impact Projection Study (GRIPS) Commission.*** GRIPS has been involved in information collection for resource, environmental, and economic data bases, and has provided a forum for discussion and cooperation among the counties and state and federal bodies.

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* See discussion in Section 4.2 above and update on status of development in Section 7.2 below.

** Rollin Russell, Vice President, McCulloch Geothermal, speaking before the Bay Area Geothermal Resources Council, August 28, 1979. See Section 7.3 for update.

*** See Section 5.23.

Future County Activities

The postures and activity levels of the four counties will probably remain the same in the near future. Until the environmental and social questions now confronting geothermal developments are addressed, development can proceed only slowly. This process will be assisted by the preparation of area-wide environmental data bases now being developed by LLL under funding from DOE. (See discussion supra, 5.12b). If the counties can be convinced that geothermal development can be made compatible with other local needs, the full potential of their resources may then be developed.

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4. State of California, Energy Commission, Exploring New Energy Choices for California, The 1979/80 Report to the Legislature, Draft, Sacramento, May 1979.

5. Kerry O'Banion, Lawrence Livermore Laboratory, September 6, 1979: communication.

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RESOURCE PROFILE
DEVELOPMENT ACTIVITIES
ENERGY SUPPLY and DEMAND
GEOTHERMAL ENERGY MARKET
GOVERNMENT ACTIVITIES and INITIATIVES

6. PRIVATE SECTOR ACTIVITIES

SIGNIFICANT EVENTS

SECTION 6: PRIVATE SECTOR ACTIVITIES AND INITIATIVES

This section discusses various aspects of the private sector geothermal development process. Section 6.1 summarizes the existing and projected levels of investments in leasing, drilling, and development activities at different sites. An important aspect of the development process is the availability of capital to support various geothermal projects. Section 6.2 examines emerging project financing mechanisms, such as reservoir insurance, leverage leasing, and interim-risk-assuming companies. As the industry matures, a number of institutions have emerged to meet the participants' needs for information dissemination and representation. Section 6.3 describes the programs of the Geothermal Resources Council and the Electric Power Research Institute. DOE efforts to assess industry perceptions of government initiatives and programs are highlighted in Section 6.4.

6.1 PRIVATE SECTOR INITIATIVES

In response to rapidly rising prices for conventional fuels, and lengthening delays in conventional power plant siting, private industry has increased its capital investment and activity in all phases of geothermal energy production. Three indicators of private sector commitment are; bidding for federal lease sales, utility investment in power plant construction, and industry-funded pilot projects. These activities are described below to illustrate the heightened involvement of the private sector.

Federal geothermal lease sales in California for 1974-1979 are presented in Table 6.1-1.

Table 6.1-1. Federal Geothermal Lease Sales in California 1974-1978*

KGRA	Number of Sales	Total Acreage	Amount
East Mesa	3	18,729.00	$ 1,460,100.38
Geysers-Calistoga	4	14,801.59	24,115,522.66
Lake City/ Surprise Valley	1	10,583.62	134,432.75
Mono-Long Valley	1	5,482.99	632,818.43
Wendel-Amadee	1	1,205.20	1,687.28
Total	10	50,802.40	$26,344,661.50

Source: USGS. Federal Geothermal Lease Sales in California, Cumulative Statistical Bid Recap FY 1974-1978.

*Actual acreages leased by B.L.M. subsequent to sales may differ slightly.

While the individual bids cannot be compared Federal Geothermal Lease Sales in California 1974-78 because of differing site characteristics, the total investment of over $26 million is a significant amount which will provide a continuing impetus to development. Current state leases cover roughly 6,700 acres, much less acreage than federal leases within California.* Annual rents on the competitive leaseholds is one dollar per acre, with provision for additional bonus or royalty payments.**

The four largest electricity utilities in California are actively pursuing geothermal options. Pacific Gas and Electric (PG&E) has been involved at The Geysers dry steam field since 1958,[1] and has continually increased its generating capacity and capital investment there. The Sacramento Municipal Utility District (SMUD) is now proceeding with development plans at The Geysers, while both Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E) have announced plans for power plant construction in the Imperial Valley. Tables 6.1-2 and 6.1-3 present investment summaries for PG&E and Southern California Edison, respectively.

The PG&E investments, which now approach $100 million, underscore the economic advantages now enjoyed by geothermal steam at The Geysers-Calistoga area.*** With increased reservoir operating experience, the number of developers and users there has also increased. Northern California Power Agency (NCPA), SMUD, and DWR are now proceeding with power plant plans and at least six new developers are involved in drilling and steam production.[1]

The investments of SCE and SDG&E, on the other hand, denote an important industry commitment toward electricity production from liquid-dominated resources. As the costs of fossil and nuclear fuel sources continue to rise, hot water generating facilities have become more competitive. These two utilities provide important leadership for geothermal development in the Imperial Valley.

Another indicator of the interest in geothermal development is the extent of exploratory drilling activity. Table 6.1-4 summarizes drilling activity for 1977 and 1978 in California.

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* See update of state leasing activities in Section 7.3 below.

** Private leaseholders are not included as a measure of activity because most privately held land with geothermal potential has already been leased, and current activities are difficult to track. See Section 2.12, Private Lands.

*** For the 1976 operating year, PG&E geothermal plants produced electricity for 25% to 50% less per KWH than nuclear, coal, or oil-fired plants.[2]

Table 6.1-2. Pacific Gas & Electric Company - Geysers Geothermal Investments 1960-1984

Date of Commercial Operation	Location	MW	Steam Producer	PG&E Capital Investment
1960	Geysers 1	11	U-M-T*	$ 4,010,000
1963	2	13	U-M-T	
1967	3	27	U-M-T	7,610,000
1968	4	27	U-M-T	
1971	5	53	U-M-T	12,756,235
1971	6	53	U-M-T	
1972	7	53	U-M-T	11,520,287
1972	8	53	U-M-T	
1973	9	53	U-M-T	13,520,000
1973	10	53	U-M-T	
1975	11	106	U-M-T	19,666,242
1979	12	106	U-M-T	27,580,000
1979	15	55	Thermogenics	25,530,000
1980	13	135	Aminoil	28,934,000
1980	14	110	U-M-T	27,966,000
1982	17	110	U-M-T	41,592,000
1982	16	110	Aminoil	42,700,000
1982	18	110	U-M-T	48,882,000
1983	19	110	Aminoil	48,800,000
1984	20	110	U-M-T	52,284,000
1984	21	110	U-M-T	52,221,000

Source: PG&E, San Rafael, California, February 1979.

Notes: Capital investment excludes land, transmission and fuel costs. Steam supply for units 19, 20 and 21 has yet to be proven.

*U-M-T = Union Oil, Magma Power and Thermal Power.

It is interesting to compare the increased interest in the Imperial County KGRAs with the drilling at The Geysers. In 1978, drilling footage increased by 115% (from 50,058 to 107,567 feet) in the Imperial Valley from 1977, while in The Geysers, drilling footage actually decreased by 9% (from 260,465 to 237,481) although The Geysers area still accounted for about 70% of the drilling activity.

The pilot projects in the Imperial Valley provide a more explicit illustration of private sector initiatives to expand geothermal development. Technological and economic

Table 6.1-3. Southern California Edison - Anticipated Geothermal Investments, 1980-1986

Date of Commercial Operation	Location	MW	Producer	SCE Capital Investment
1980	Brawley	10	Union	$18,000,000
1982	Salton Sea/ Niland	10	Union/ S.P. Land	18,000,000
1982	Heber	50	Chevron	63,000,000
1984	Brawley	100	Union	N/A
1985	Brawley	100	Union	N/A
1985	Salton Sea/ Niland	40	Union/ S.P. Land	N/A
1986	Brawley	100	Union	N/A

Source: Third Annual EPRI Conference, Monterey, California, June 26-29, 1979.

uncertainties* associated with electricity production from hot water resources arise because brine production facilities and generation plants have not yet been built and demonstrated on a commercial scale in the United States.[3] To reduce these uncertainties, actual operating information is needed. It is generally held that the most economical means to acquire such data is through pilot power plants[4] so that the risk to producers, investors, lenders, and utilities can be minimized.[5]

There is one operating pilot plant in the Imperial Valley and three others are in the design or construction stages.* They are the first hot-water plants in California and are additionally significant because they employ different conversion systems. The three systems to be used (single phase flash, double phase flash, and binary) have different strengths and weaknesses depending on the characteristics of the resource used.** The pilot plants will

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* The production risks hinge on the inability to clearly define reservoir characteristics, and the costs and performance of a production system. The conversion risks center on ill-defined efficiencies and economics of the three plant conversion modes: single flash, double flash, and binary.

* See update on site-specific developments in the Imperial Valley, Section 7.2 below.

Table 6.1-4. Geothermal Drilling Activities in California, 1977 & 1978.

Area	Operator	Wells 1977	Wells 1978	Footage Drilled 1977	Footage Drilled 1978
The Geysers	Union	15	13	123,404	114,932
	McCullough	2	2	13,023	15,962
	Thermogenics	0	4	0	
	Shell	6	2	50,849	24,304
	Aminoil	8	4	65,843	31,823
	Republic Geothermal	1	0	7,376	0
	Occidental	0	1	0	9,514
	Phillips	0	1	0	6,000
	AMAX	0	1	0	8,760
Coso Hot Springs	CER Corporation	1	0	4,846	0
Imperial Valley	Republic Geothermal	5	2	29,424	10,945
	Magma	1	5	3,095	28,342
	Union	1	4	9,609	44,880
	Chevron	1	1	7,930	10,019
	McCullough	0	1	0	13,381

Source: Smith, et. al., "Summary of Geothermal Drilling," Geothermal Energy Magazine, Vol. 7, No. 5, May 1979.

provide information on all three systems for utilities and other operators involved in plant design decisions. Optimization of the conversion system is crucial if operating costs are to be minimized, and the information from the pilot plants will be extremely useful.

The first pilot plant to come on-line is a 10 MWe binary unit developed by Magma Power and SDG&E. The facility, located in the East Mesa area, is the first binary system in the United States.

SCE is presently involed in three hydrothermal projects. Union Oil and SCE are nearing completion of a 10 MWe single flash pilot plant at Brawley to demonstrate steam generation with high-temperature, high-saline brines.[6] If the plant proves successful, SCE expects to build a 100 MWe commercial plant as the first step to further expansion. Under the cooperative agreement between Union Oil and SCE, Union Oil will act as the field developer and steam producer, while SCE will finance, own, and operate the plant. A 50 MWe SCE unit at Heber is now in final design stages and is scheduled for completion in late 1982. Chevron will provide low saline brine for the "double flash" plant which will be the first of its type in the U.S. A third SCE project focuses on the Salton Sea area, probably the hottest and largest anomaly in the Imperial Valley.[6] Union Oil, Southern Pacific Land, and Mono Power Company are leaseholders there, and Union will act as operator for field development and production activities. A 10 MWe power plant is planned to be on-line in mid-1982. SCE is especially interested in Brawley and Salton Sea for future development, if the pilot plants can be operated successfully at competitive costs.

An important commercialization issue is how utilities and developers will continue to finance development activities and work together with local governments to preserve the communities' quality of life in the future. How these different entities share risks and rewards will affect the rate of development in California.

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6.2 FINANCIAL INSTITUTIONS ACTIVELY SUPPORTING GEOTHERMAL DEVELOPMENT

INTRODUCTION

The capital intensiveness of resources exploration and development activities, the 7-9 years (from beginning of field development) lead time prior to receipt of production revenues, and uncertainty over reservoir reliability, have contributed to the difficulty of financing geothermal projects for developers, utilities, and lenders alike. The general dilemma is that the financial community needs more demonstrations of successful, operating projects before it can extend financing and the industry needs venture capital to fund those demonstrations. However, each of these participants has a different acceptable level of risk. The level of acceptable risk to investors at the exploration and development stage is generally considered to be the highest; and in order for development to proceed, the transition from one level of risk to another must be made.

A geothermal developer needs to overcome two financial obstacles. He must first be able to support the resources assessment necessary to establish a viable resource, then acquire additional funding to bring the field to production. Each of these efforts requires a different type of financing mechanism.

Exploratory drilling, or "wildcatting," is traditionally considered the place for risk capital. A firm will need to finance these ventures primarily with its own equity, or by forming limited partnerships that include outside investors.[1] Financing or leasing arrangements may be available for certain types of equipment involved in exploration, but it would depend on the company involved.

Traditional lending institutions are more likely to become involved during the second phase, that of bringing the resource to production. Once a developer can satisfy independent observers that there is an adequate and economic resource, and that a market for future steam or hot water production exists,* commercial lenders will consider project financing for field development or actual production.**

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* Acceptable evidence of a market may be in the form of a steam contract or a power plant commitment.

** The timing and thrust of project financing can vary. Loans usually would be either for field development (a 2-4 year process prior to production), or for actual production (at the time it begins). The latter is inherently less risky, as production is proven and markets are likely to be more secure.[2]

However, lack of established reservoir evaluation techniques and difficulty of acquiring firm commitments from buyers (partially because of reservoir reliability issues) still make this type of loan very risky.* Commercial banks are reluctant to undertake such projects without some form of additional assurance, such as a loan guaranty.

The primary investment made by utilities and other producers of electricity is for construction of the power plant, and financing is typically spread over a longer term than for exploratory and development activities. Although the financial needs differ from those of developers, they also have to deal with the problem of reservoir reliability. Long-term debt instruments which would normally cover relatively secure investments and carry a lower interest charge may not be readily available because of the risks associated with geothermal reservoirs and new conversion techniques.** Prospective borrowers are again confronted with the need for secondary backing.

In summary, the problem of finding adequate sources of venture capital is a continuing issue for geothermal developers. The "bottom line" for prospective investors is whether the expected return is commensurate with the risk. Both the federal and state government and the private sector are seeking new arrangements to decrease the front-end capital needed or to increase the availability of venture capital, or both.*** Their relationship to major financial vehicles currently available and some possibilities for the future are discussed below.

GEOTHERMAL PROJECT FINANCING

The National Energy Act of 1978 included a number of tax measures designed to stimulate geothermal exploration and development by increasing its attractiveness as an investment. The tax provisions are in three parts: (1) Depletion Allowances, (2) Intangible Drilling Cost Expenses, and (3) Investment Tax Credits for business and residential applications. Each of these, in a different manner, affects the expected after-tax return on investment (ROI) from a

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* Reservoir insurance has been proposed to help mitigate this problem and will be discussed later in this section.

** See also the discussion in Section 6.1 on pilot projects.

*** A summary of National Energy Act provisions is presented in Appendix 1. See also the description of the Energy Security Act of 1980 in Section 7.3 below.

geothermal venture. As the expected return increases, it will compensate for a portion of the risk associated with geothermal development, and therefore increase the likelihood of participation by the investment community.

The Geothermal Loan Guaranty Program (GLGP), administered by the Department of Energy, plays an important role in geothermal financing (see Section 5.12). By providing loan security, the GLGP encourages the financial community to participate in capital-intensive geothermal projects that would otherwise be deemed too risky. Three banks are now involved in the program and many more are interested. Bank of America and Bank of Montreal (California) are participating as primary lenders, and Bankers Trust is acting as a trustee in a long-term private placement. The two activities are very different and highlight the varied roles commercial banks can play.

As primary lenders, the banks can provide short-term financing for field development or construction. The maximum term is ten years and repayment comes from future operating revenues. The project must be economically feasible, and have a reasonable assurance of repayment before a guaranty will be granted. The guaranty does not decrease the risk, but instead provides additional security, without which the bank would not undertake the loan.

Private placement is used primarily to secure long-term loans (10-30 years) at fixed rates from lenders such as insurance companies, pension funds, and bond holders that desire steady returns for income purposes. In these instances, the bank serves as a trustee and provides the necessary loan servicing. Loans such as these need a greater assurance of repayment to compensate for their greater length and lower interest charges.

The existing GLGP private placement is with the Georgia State Retirement System through Bankers Trust in New York. It is for a food processing plant where the technology is proven and resource verified. Hydrothermal electrical generating facilities will need to demonstrate their reliability before this money market can be useful to their financing needs.

The GLGP has spurred the interest of lending institutions in financing of geothermal electrical projects. Banks are gradually increasing their familiarity with geothermal development, and successful demonstration projects will raise their confidence. While the outlook is promising, the traditionally conservative nature of the financial community suggests that geothermal investments will come slowly.

There is continuing need for financing methods not requiring governmental support. Private developers and financiers are attempting both to adapt present financing options and to develop new alternatives that address the special needs of the industry. Tax leverage leasing is a presently available option, while interim risk-assuming companies and reservoir insurance are much discussed alternatives that may come about in the future.

<u>Tax Leverage Leasing</u>

Tax leverage leasing is a form of financing that could be adopted from other capital-intensive projects.* The advantages of this type of lease arrangement for geothermal power plants are fourfold: (1) the developer and the utility/producer are relieved of the need for a large capital investment, (2) the utility is relieved of the risks associated with plant construction, (3) the developer can avoid the risk of being regulated,** and (4) tax benefits may be realized which may be unavailable to the utility as a plant owner.[3]

A tax leverage lease transaction for a power plant would require three participants (a lessor, a lessee, and a lender).[3] The key to a tax leverage lease transaction is the lessor, or equity investor, because the initial investment capital carries the greatest risk.*** The primary attraction here is the tax benefits that can accrue to the investor. By borrowing a major portion of the investment and keeping title to the equipment, the equity holder can receive 100% of the tax benefits, while contributing only 20-25% of the total funds. Thus, the lessor can leverage his investment to acquire greater rewards through successive reduction of his original invested capital through lease payments.

The lessor would arrange to lease the equipment to the lessee (typically a utility) for a commitment of regular payments over its useful life. The lessor would provide the equity investment for the equipment (usually 20% to 25% of the total) and borrow the rest from a lender.+ The lease payments and the first lien on the equipment would be assigned to the lender to acquire the loan.++

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* Notably airplane and computer purchases.

** The risks of utility regulation are discussed supra Section 5.12.

*** The lessor transfers his right to first payment to the lender. In addition, if the GLGP is used, it will only cover the lender's 75% investment.

+ Lenders here can include banks, insurance companies, pension funds, etc.

++ The lease payments would normally be unconditional, i.e., payable under any circumstances. It is possible that the GLGP could be used as additional security for the loan.

Tax benefits received by the lessor may also be shared with the lessee through lower lease payments. It is here that tax leverage leasing is especially applicable to geothermal development because, under current federal tax provisions, utilities are not eligible for the added 10% investment tax credit allowed for geothermal investments.** Through the mechanism of tax leverage leasing, the utility can receive indirectly through the lessor a portion of tax benefits it may not be allowed directly. This may improve the economic attractiveness of a geothermal venture.

The tax-leveraged lease also shelters developers from possible regulation and relieves them of any additional capital requirements. The utilities are likewise relieved of pressing capital needs and can benefit indirectly from tax incentives not otherwise available to them. Lenders receive a return on the loan and commitments for steady cash inflows. Most importantly, equity investors acquire the tax benefits necessary to attract their capital, along with a reasonable return and any residual value arising from the ownership of the equipment.

Interim Risk-Assuming Companies

Two additional financing options that have been suggested to aid geothermal development are "Interim Risk-Assuming Companies" (IRAC's) and reservoir insurance. While very different in scope, both could be extremely useful financial vehicles for the industry.

Interim Risk-Assuming Companies have been proposed as possible links between the developer and the utility. In the financing of pilot projects and early demonstration plants, the IRAC would enter into an agreement to purchase steam directly from the developer, and to finance, construct, and operate the power plant necessary for electric generation, and sell the electricity to a utility.[4] This would provide for an early return on investment and alleviate the risk to the developer of utility regulation, while relieving the utility of capital investment until adequate operational performance has been shown.

Reservoir Insurance

Reservoir reliability is a major concern to both lenders and investors in geothermal ventures. To mitigate this, various forms of reservoir insurance have been discussed by both the public and private sectors.* Reservoir

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** See Appendix 1 for a further description of investment tax credits.

* See description of Energy Security Act provisions in Section 7.3 below.

insurance is a means for a utility or plant operator to protect his investment against the possibility of reservoir depletion.

Corron & Black of Pennsylvania, an insurance broker, has announced plans to provide reservoir insurance and match geothermal developers with major insurance companies.[5] The program they propose would break the coverage period into development and operations phases. The first phase would follow an evaluation of reservoir reliability by independent experts, and would cover the field development and plant construction until the plant is completed and operating. The parties involved in field development and plant construction could be underwritten separately to address their particular needs. In the case of "reservoir inadequacy" or certain other named perils, such as fires or earthquakes, the insured parties would be indemnified for cumulative project costs incurred for plant and equipment completed. In the operational phase the extent of coverage would depend on the specific needs of the insured, and would be payable under the same circumstances.

This is the first private venture offering reservoir insurance, and the parameters of the program are not yet well defined. The specific characteristics and risks associated with each reservoir and prospective party may require very different insurance coverage, and the cost and availability of such coverage will vary accordingly.

Domenic Falcone (of Geothermal Resources International) has proposed a reservoir insurance plan whereby the time frame for field development and power plant construction can be dovetailed, and thus reduced.[6] He proposed that insurance companies underwrite policies which would insure purchasers of steam from reservoir failure for a period of 3-5 years. This would be subject to a developer's showing sufficient data to indicate an economic resource to support electricity generation. Utilities could then begin power plant construction before full field development is complete. In case of reservoir failure, the utility would be indemnified for all capital investments in place.

All parties would benefit. The developer would benefit from early steam and plant operation. The savings the developer recognized in the form of decreased financing charges (interest), would then be used to pay the insurance premiums, with any savings exceeding the premiums being an added benefit. In addition, utilities benefit by earlier additions to capacity.

To date, a number of insurance companies have expressed an interest in this proposal. It is hoped that reservoir insurance will come about as knowledge of resource characteristics increases, providing an additional mechanism for transition from one level of risk to another.*

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* See update on reservoir insurance developments, Section 7.4 below.

6.3 PRIVATE SECTOR INFRASTRUCTURE DEVELOPMENT

INTRODUCTION

Effective exchange of information between government and industry is essential to the commercialization of geothermal energy. An example of cooperative technology development is the industry participation in DOE's materials and technological research programs, engineering and economic feasibility studies, and field demonstrations. Within the private sector, information dissemination is supported by several organizations. The Geothermal Resources Council (GRC) supports a program covering all phases of the geothermal industry, while the Electric Power Research Institute (EPRI) concentrates primarily on the utility aspects of geothermal development. In addition, the Geothermal Energy Committee of the American Society for Testing and Materials (ASTM) was established to oversee the development of technical standards for the geothermal industry. Their programs are described below.

THE GEOTHERMAL RESOURCES COUNCIL

The Geothermal Resources Council (GRC) was formed in 1972 as a non-profit organization. Members include representatives from all sectors of the industry, and the emphasis is on the interchange of information and ideas to promote geothermal development. To accomplish this, the council serves both as an educational forum and a coordinating body for information regarding geothermal energy and its advancement.

The primary focus of the GRC's activities is the educational program. The GRC sponsors a number of short courses, workshops, and conferences on both technical and managerial considerations. In addition, the annual meeting is structured around issues crucial to the industry. GRC-sponsored short courses, workshops, and meetings in 1978-1979 included:

"Direct Utilization of Geothermal Energy: A Symposium," Jan.-Feb. 1978, San Diego, CA (DOE Contract), publication.

Special Short Course #7, "Geothermal Energy: A National Opportunity (The Federal Impact)," Washington, D.C., May 1978.

Annual Meeting, "Geothermal Energy: A Novelty Becomes a Resource," Hilo, HI, July 1978.

"LLL/GRIPS Workshop on Environmental Technology for The Geysers-Calistoga KGRA," Oakland, CA, Oct. 1978 (LLL Contract).

"A Conference on the Commercialization of Geothermal Resources," San Diego, CA, Nov. 1978 (Partial support from California Energy Commission).

A Symposium on Geothermal Energy and its Direct Uses in the Eastern United States, Hot Springs, VA, April 1979 (DOE Contract).

Special Short Course #8, "An Introduction to the Exploration and Development of Geothermal Resources," South San Francisco, CA, May 1979.

Annual Meeting, "Expanding the Geothermal Frontier," Reno, NV, Sept. 1979.

The GRC also distributes a newsletter, conference reports and publications. A list of publications is included at the end of Section 6.3.

In addition to the national organization, the GRC is divided into regional sections with their own officers and programs. There are currently five regional sections: Rocky Mountain Section; Bay Area Section; San Diego Section; New York Section; Basin and Range Section (Utah and Eastern Idaho). New sections are also being formed in Reno, Nevada, Sacramento, California, Washington, D.C., and Dallas, Texas. Each region supports regular meetings, field trips, and other functions which allow for information interaction of the participants involved in geothermal development.

The Bay Area Section (San Francisco, California) of the GRC has approximately 60 members. Among other activities, the group regularly sponsors a guest speaker or discussion at their monthly meetings. The topics cover all phases of geothermal development, and in the past year have included project financing, nonelectrical applications, pricing problems, the U.S. resource assessment, and the institutional environment.

THE ELECTRIC POWER RESEARCH INSTITUTE

EPRI was founded in 1972 by utilities to develop and manage a national technology program for electric power production, distribution, and utilization.* More than 500

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* EPRI's range of activities include: engineering evaluations of fossil and nuclear power plants, environmental assessments of power generation options, energy supply and demand analysis, energy storage research, transmission line equipment design, nuclear power plant safety studies, utility rate designs, health effects of power plants, and analysis of new energy resources.

investor-owned, cooperative, federal, and municipal utilities support EPRI's research program.

The New Energy Resources Department, which oversees research for fusion, solar, and geothermal energy, is part of the Fossil Fuel and Advanced Systems Division. Since 1977, EPRI has reported on the electric utility industry's forecast of geothermal generating capacity. The geothermal program has three subprograms: (1) Hydrothermal Resources, (2) Advanced Technology, and (3) Geopressured Resources. Each of these subprograms will be discussed separately.

Geothermal Program, Commercialization Activities

The geothermal program at EPRI is designed to accelerate commercial adoption of current technologies for geothermal development. This is supported by the accumulation of relevant data bases, and engineering and economic analyses. Additionally, EPRI is committed to promoting the development of hydrothermal (hot water) resources and geopressured resources. Both of these types of resources are more prevalent than vapor-dominated resources, and are considered economically and technologically feasible to develop. EPRI's near-term efforts are concentrated on low-salinity hydrothermal resources because: (1) low-salinity resources are more economical to develop (fewer scaling and water disposal problems) than high-salinity resources, and (2) low-salinity conversion technology is expected to be similar to the technology required for geopressured and igneous systems.

- Hydrothermal Resources Subprogram

A major proposal is for construction of a 50 MWe low-salinity binary cycle hydrothermal power plant by SDG&E at the Heber KGRA.* EPRI believes that a demonstration plant will provide important operational, performance, economic, and environmental characteristics. Field data will assist the assessment of the technologies and economics of power generation from hydrothermal resources. Further, environmental impacts can be quantitatively measured. The Heber demonstration plant should also provide information on; (1) reservoir development techniques, (2) reservoir management for energy conservation, (3) reservoir performance prediction, (4) binary cycle power conversion, (5) subsidence control, and (6) efficient cooling water management.

The original 1977 proposal called for EPRI to provide financial (about 10%) and technical support for design of

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* See update on the Heber demonstration plant in Section 7.2 below.

the binary plant, with the expectation that the Department of Energy would provide the additional financing necessary to bring the plant on-line by the end of 1980. This proposal was rejected by DOE in favor of a flash system proposed by Union Oil Company and Public Service Company of New Mexico.

EPRI has continued to be supportive of a binary demonstration project. It has worked with other utilities to develop a consortium in anticipation of Congressional authorization of a second demonstration project. The concept is that utilities could share the risks associated with a demonstration plant because all electrical producers would gain from the information to be learned.

- Advanced Technology Subprogram

EPRI is committed to development of advanced hardware and software systems for geothermal resources. The present projects included in this subprogram are geothermal fluid properties, fluid testing techniques and test standardization, site-to-site variability, brine system chemical kinetics, and scale control.

- Geopressured Resources

Geopressured zones occur throughout the world in deep sedimentary basins. The basins are often found at depths below 1-2 miles at pressures substantially higher than those normally found at those depths. EPRI's program is designed to evaluate and support the development of geopressured resources as a power generation option. The program includes a definition of requirements and impacts, assessment of the power potential and adequacy of the available technology, and evaluation of critical components, leading to the determination of a preferred system configuration and design of a pilot power plant. Commitments to construct a pilot plant are expected in 1981 or early 1982.

1979 Utility Estimates of Geothermal Electricity

Since 1977, EPRI has reported on the electric utility industry's forecast of geothermal generating capacity. Data for these reports were taken from two sources, formal forecasts of future generating capacity compiled by the National Electric Reliability Council (NERC) and the Western Systems Coordinating Council (WSCC), and an annual survey of selected utilities.

Based on NERC data, the national outlook in 1979 indicated a moderate increase from the 1979 level of 502 MW to about 1760 MW in 1987. This represents an annual rate of about 14%. By comparison, the expected growth rate for total electric capacity over the same period was 5.3%/annum. (See Table 6.3-1.)

Table 6.3-1. Forecasted WSCC 10-Year Generation Additions

	Total	Coal		Nuclear		Geothermal	
	(GW)	(GW)	(%)	(GW)	(%)	(GW)	(%)
1976-1985	68.5	23.5	(34)	19.1	(28)	1.57	(2.3)
1977-1986	59.7	18.7	(31)	18.6	(31)	1.71	(2.9)
1978-1987	59.7	19.5	(33)	19.6	(33)	1.76	(2.9)
1979-1988	60.4	22.8	(38)	18.7	(31)	1.82	(3.0)

*Based on Western Systems Coordinating Council 10-Year Plan Summaries

Source: EPRI, 1979.

The EPRI survey was designed to sample the mood of the industry concerning future construction of geothermal power plants between now and the year 2000.[1] Capacity forecasts for each of three levels of expectation were requested: (1) announced - either publicly or through PUC-type biennial reports; (2) probable - based on successful demonstration of technology for using liquid-dominated geothermal resources; (3) possible - based additionally on the removal of institutional barriers, governmental incentives, and R&D support. The results of the 1979 EPRI survey are shown in Table 6.2-2 and a summary of results of the survey since 1977 is shown in Table 6.3-3.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) GEOTHERMAL COMMITTEE

The ASTM Committee E-45: "Geothermal Resources and Energy" was established on October 17, 1979 to support development of standards for geothermal materials and technology.[2,3] Participants included representatives from exploration and development companies, geothermal industry associations, equipment manufacturers, government agencies, and national laboratories. Three technical subcommittees were created to cover the different aspects of geothermal operations:

- E-45.10 Field Development. The focus of this committee is on the subsurface aspects of a geothermal field. It consists of four task groups - Fluid and Gas Sampling and Analysis, Materials, Drilling, and Logging

Table 6.3-2. 1979 EPRI Utility Geothermal Survey

	Capacity (MWe) By Year				
	1977 Actual	1985 Est	1990 Est	1995 Est	2000 Est
ARIZONA/NEW MEXICO	0				
Announced		50	50	50	50
Probable		100	250	350	450
Possible		150	450	800	1000
CALIFORNIA	502				
Announced		2007	2192	2462	2782
Probable		2354	3957	5158	6108
Possible		2739	5517	7608	8858
IDAHO/OREGON/WASH	0				
Announced		0	0	0	0
Probable		0	50	150	250
Possible		0	100	250	400
NEVADA/UTAH/MONT	0				
Announced		0	0	0	0
Probable		110	320	430	430
Possible		110	375	430	430
GULF STATES	0				
Announced		0	0	0	0
Probable		0	0	20	50
Possible		0	1	100	200
TOTALS	502				
Announced		2057	2242	2512	2832
Probable		2564	4577	6108	7288
Possible		2999	6443	9188	10888

Source: EPRI, 1979.

and Surface Geophysics.

• E-45.20. Utilization. The scope of this subcommittee includes all surface aspects of the utilization of geothermal energy. The three task groups in this subcommittee are: Materials, Product Recovery, and Energy Utilization Systems.

Table 6.3-3: Comparison of the Annual EPRI Surveys

	U.S. Geothermal Electric Power Capacity (MW)			
	1985	1990	1995	2000
Announced				
1977	1178	1378	1678	1828
1978	2019	3019	3619	3919
1979	2057	2242	2512	2332
Probable				
1977	2528	3258	4358	5358
1978	2664	5414	7473	9023
1979	2564	4577	6108	7288
Possible				
1977	2858	4268	6268	8868
1978	3374	7664	11323	14723
1979	2999	6443	9188	10888

Source: EPRI, 1979.

- Geothermal Residuals. This committee is responsible for the characterization, abatement, and disposal of geothermal residuals. Task groups include: Characterization, Disposal, Abatement, and Reclamation.

Those interested in the Geothermal Resources and Energy Committee should contact:

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1. V. Roberts and P. Kruger, Utility Industry Estimates of Geothermal Electricity, Electric Power Research Institute, Palo Alto, California, presented at the Third Annual Geothermal Resources Council Conference, September 3, 1979.

2. ASTM Press Release, October 1979.

3. Doug Stockton, Division of Oil and Gas, Department of Conservaton, February 1980: communication.

6.4 PRIVATE SECTOR PERCEPTIONS OF GEOTHERMAL DEVELOPMENT

The emerging geothermal industry includes participants from a number of sectors and is continuously expanding through the entry of new participants. They include oil companies, utilities, exploration companies, banks, engineering firms, and agricultural and manufacturing enterprises. An appreciation of the developing character of the industry may be gained from a review of the Geothermal Resources Council's Annual Roster. Table 6.4-1 compares 1977 and 1978 registrants under various categories. It should be noted that the rate of increase in participation differs among the categories.

Table 6.4-1. Geothermal Industry Participants 1977 and 1978

	1977	1978	Rate of Increase
Operators	67	122	182%
Utilities	17	34	200
Support Services	260*	413	159
Hardware/Supply	35	80	229
Financial	11	38	345
Direct Applications	-**	21	N/A
Total	390	708	182%

Sources: 1977; The Geothermal Registry, Geothermal Resources Council, 1977. 1978; Rex, Robert, "U.S. Geothermal Industry in 1978," Geothermal Energy Magazine Vol. 6, No. 7, July 1978.

*Includes consultants, drilling companies, engineering firms, service companies, and others.
**Direct applications were not given a specific category in 1977.

Geothermal Industry Participants, 1977 and 1978, Geothermal Resources Council Roster

Design of government commercialization initiatives should be predicated on an understanding of the structure of the geothermal industry and this industry's perception of the effectiveness of government activities. The preceding sections show that there is a significant amount of development activity, reflecting increasing interest in geothermal development. The Department of Energy has funded two separate projects in an effort to evaluate private sector perception of governmental initiatives. A survey of geothermal developers was conducted by Booz-Allen and Hamilton. Concurrently, the Earl Warren Legal Institiute carried out a study of the legal, institutional, and economic barriers facing geothermal direct use applications. The preliminary findings of these studies are presented below.

THE BOOZ-ALLEN HAMILTON STUDY[2]

The Booz-Allen study had four primary tasks: (1) to clearly define the existing and potential geothermal market; (2) to assess the structure, operations and interactions of the private and public sectors of the current geothermal industry; (3) to analyze the perceptions and objectives of industry members with respect to geothermal development, including reactions to current and proposed federal commercialization initiatives; (4) to design a system to monitor industry perceptions of government activities and arrange a means of better integrating state and federal plans.

An interesting finding was that the geothermal industry is very small, consisting of approximately 30 principle firms, and that others do not intend to move rapidly into the field.* There is a clear interest in geothermal development, but there presently exist significant barriers to its expansion. In addition, development for electrical uses is currently perceived to be more profitable than direct applications.

While geothermal ventures offer attractive opportunities, there is a reluctance at all levels to proceed with development. Institutional uncertainties and reservoir reliability pose the major obstacles to increased activity. The federal government still does not have a well defined geothermal energy policy, and this precludes the investment of large amounts of risk capital. Regulatory policies have not been clearly set forth. The resulting environmental and other regulatory delays can result in debilitating interest costs if invested capital sits idle. These uncertainties and the risks of general regulation and possible penalties pose a major deterrent to developers. For utilities and the financial community, the risk associated with reservoir characteristics continues to be a major problem. Many utilities lack the resources to undertake geothermal ventures by themselves, and lending institutions are still reluctant to

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The large companies involved are interested primarily in electrical generation. This was precipitated by the problems and attendant costs of power production from more conventional fuel sources. Limitations have been imposed on the use of oil and gas, nuclear plants have long lead times and regulatory risks, while coal is rising in price and is affected by stiff air quality standards.

commit capital to what they regard as unproven technology.

The attitudes of state and local governmental bodies towards geothermal activities can also have a definite impact on their likely success. In general, Utah and New Mexico have not fully accepted development of geothermal resources, whereas Hawaii and California have incorporated geothermal resource development into their energy supply planning. In states that do encourage utilizaton, the questions are "How can the process be accelerated" and "What are the major stumbling blocks?" In particular, two major points were highlighted for California. The first is that counties hold a substantial amount of power through regulatory control and are thus a key to geothermal development. The second is that compared with development in northern California, there are fewer obstacles to development in southern California and it is easier to get projects underway.

THE EARL WARREN LEGAL INSTITUTE STUDY

The Earl Warren Legal Institute has completed a study for the Department of Energy to assess the barriers facing nonelectric and small-scale electric geothermal applications.[4,5,6,7] The project was designed to identify the primary actors, the institutional structures, and the major decision-making factors associated with hydrothermal development. An analysis of the decision-making processes and environments will enable government entities at all levels to better structure incentives and programs to speed commercialization.

The project has developed a conceptual model to identify the potential users and institutional structures most applicable to hydrothermal use. Using the model as a base, 60 firms were interviewed in key industries such as greenhousing, food processing, lumber milling, and chemical production. Responses by interviewees provided a sample of users' perceptions of the legal and institutional obstacles to commercializaton and clarified their attitudes toward various government initiatives.[4,5] The Institute is also examining a number of legal issues associated with direct heat applications including alternative financing options and public utility regulation of direct heat suppliers.[6,7,8] Critical legal problems associated with geothermal development are also being evaluated, including public sector legal and financial options, and various aspects of public utility regulation.

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3. John Nimmons, The Geothermal Commercialization Study, EWLI Memo, August 10, 1979.

4. Alternative Institutional Structures for the Commercialization of Geothermal Energy Resources, an Interim Report Submitted to the Department of Energy, December 20, 1978.

5. Legal and Institutional Considerations in the Commercialization of Geothermal Resources for Direct Uses, Second Interim Report, February 22, 1979.

6. Overview of State Public Utility Regulation Impact on Geothermal Direct Heat Applications, April 23, 1979.

7. State-by-State Analysis of Public Utility Laws Affecting Geothermal Direct Heat Applications, (Draft), June 26, 1979.

8. J. T. Nimmons, State Public Utility Regulation of Geothermal Direct Heat Suppliers, Earl Warren Legal Institute, University of California, Berkeley; presented at the Third Annual Geothermal Resources Council Conference, September 3, 1979.

RESOURCE PROFILE
DEVELOPMENT ACTIVITIES
ENERGY SUPPLY and DEMAND
GEOTHERMAL ENERGY MARKET
GOVERNMENT ACTIVITIES and INITIATIVES
PRIVATE SECTOR ACTIVITIES

7. SIGNIFICANT EVENTS

SECTION 7 SIGNIFICANT EVENTS

This section presents materials which supplement and update previous sections of the Planner's Guide. Included are excerpts from recent publications relevant to geothermal energy and development in California. Selections are organized to parallel roughly the organization of the Planner's Guide. Recent activities at particular geothermal sites are presented first (Sections 7.1, 7.2); then, state and federal programs for geothermal energy commercialization are updated (Section 7.3). Each update is followed by a notation indicating the particular publication from which it is excerpted. The notation is contained in the square brackets at the end of each publication described below.

FEDERAL GOVERMENT PUBLICATIONS

- Geothermal Progress Monitor Report (DOE) is a quarterly publication of the Division of Geothermal Energy. The Report was created in late 1979 for DOE headquarters and field staff reports of commercialization activities throughout the United States. It provides non-technical summaries of development activities, such as drilling and exploration, and describes legal, institutional, and regulatory activities. Recent reports and publications are also abstracted. [GPM -number]

- Geothermal Commercialization Data Base (DOE) is administered by Lawrence Berkeley Laboratory for DOE. The data base summarizes resource characteristics and activities at over seventy geothermal sites in fourteen states. Status reports are issued quarterly. GRAD is also part of the NPMS. [GRAD]

- Geothermal Energy Program Summary Document (DOE) is the annual report to Congress by the Assistant Secretary for Resource Applications, supporting budget requests by the Division of Geothermal Resources Management. It describes DOE organizations and programs, and summarizes recent and proposed activities. [PSD]

- Annual Report (Federal Interagency Geothermal Coordinating Council) describes recent and proposed geothermal activities of the nine member agencies. Individual programs and projects are discussed in the context of meeting IGCC energy production goals. [IGCC]

CALIFORNIA STATE GOVERNMENT PUBLICATIONS

- California Geothermal Coordinating Council minutes. Representatives of the member agencies, as well as other governmental and private organizations meet monthly. All aspects of geothermal energy commercialization are discussed with an emphasis on developing cooperative policies and activities to further encourage development. [CGCC]

- Geothermal Hotline (Division of Oil & Gas, Department of Conservation). This biannual magazine summarizes development activities, cooperative agreements, conferences, and publications dealing with worldwide geothermal energy activities. [GHL]

- Geothermal Energy Updates (California Energy Commission) periodically summarizes the most recent activities within the state in all aspects of geothermal commercialization. [GEU]

INDUSTRY PUBLICATIONS

- Geothermal Resources Council Bulletin is a monthly newsletter describing Council activities, and reporting development, regulatory, and technical activities. The GRC also publishes the proceedings of its annual conference, and other meetings. [GRC, date]

- Electric Power Research Institute (EPRI) publishes reports of studies it sponsors in the U.S. A broad range of topics are covered, mostly technical. [EPRI]

7.1 EXPLORATION AND LEASING ACTIVITIES

EXPLORATION ACTIVITES

Clear Lake Basin

Occidental Geothermal and Republic Geothermal jointly discovered a hot water reservoir north of The Geysers in the Clear Lake Basin, after unsuccessful drilling in the area at Mt. Konocti and Thurston Lake. [GPM-3]

The Geysers

During the period January 1 - June 30, 1980, the California Division of Oil and Gas approved drilling permits for nine geothermal wells in The Geysers field. Operators receiving permits include Union Oil Co. of California (7 wells), Aminoil USA, Inc. (1 well), and Thermogenis, Inc. (1 well). [GHL, 10-2].

Lake County

Phillips Petroleum filed an NOI with the California DOG to drill two geothermal test wells east of Clear Lake. Phillips anticipates tapping a hot water reservoir for electricity production. [GPM-3]

Imperial County

Occidental Geothermal is drilling at Glamis and East Mesa. [IGCC]

San Bernardino County

Phillips Petroleum is carrying out exploration studies near West Mesa and Chocolate Mountain. [IGCC]

Mono County

Phillips Petroleum plans drilling activities near Mono Lake. [IGCC]

LEASING

BLM Lease Sale Schedule Update.

Lease sale dates are provided by the state directors of the U.S. Bureau of Land Management (BLM). (See Table 7.1-1) Lease sale dates are tentative; initial public notice is issued 30 days prior to sale. [GHL, 1/80]

Table 7.1-1 BLM Lease Sale Schedule Update

Date Notice Received	Operator, Well No.	API No.	Sec. T. R.	Location, Elevation
1-14-80	Union Oil Co. of Calif. "DX State 4596" 47	097-90440	7 11N 8W	Fr. SE cor. 548m. N, 91m. W. 964m. KB.
4-8-80	Aminoil USA, Inc. "M and W" 1	033-90291	22 11N 8W	Fr. SE cor. 307m. N, 155m. W. 778m. KB.
4-17-80	Thermogenics, Inc. "Rorabaugh" A-14	097-90445	14 11N 9W	Fr. SE cor. 336m. N, 610m. W. 659m. KB.
5-12-80	Union Oil Co. of Calif. "DX State 4596" 48	097-90447	7 11N 8W	Fr. SE cor. 555m. N, 102m. W. 964m. KB.
5-12-80	Union Oil Co. of Calif. "DX State 4596" 49	097-90448	7 11N 8W	Fr. SE cor. 559m. N, 114m. W. 964m. KB.
5-26-80	Union Oil Co. of Calif. "NE Geysers Unit" 7	033-90277	4 11N 8W	Fr. SW cor. 173.7m. N, 579.3m. E, 861.62m. KB.
5-28-80	Union Oil Co. of Calif. "NE Geysers Unit" 3	033-90278	5 11N 8W	Fr. SE cor. 731.5m. N, 362.7m. W. 812.82m. KB.
5-28-80	Union Oil Co. of Calif. "NE Geysers Unit" 10	033-90280	4 11N 8W	Fr. SW cor. 167.6m. N, 570m. E. 861.62m. KB.
5-28-80	Union Oil Co. of Calif. "NE Geysers Unit" 11	033-90281	5 11N 8W	Fr. SE cor. 731.5m. N, 347.5m. W. 812.82m. KB.

Source: Division of Oil and Gas, Geothermal Hotline, July 1980.

Sonoma County

The State Lands Commission (SLC) received 18 bids for three parcels offered for bidding in March 1980. [GEU, 3/80] On April 24, 1980, approximately 839 acres were leased for percentages of net profit plus fixed royalties of 12.5% of gross revenue and an annual rental of $1 per acre. The Sacramento Municipal Utility District (SMUD) was the highest qualified bidder for Lease 1 (approximately 599 acres) for 71% of net profits. Geothermal Power Corporation of Novato was the high bidder for Lease 2 (40 acres) and Lease 3 (200 acres), with a bid of 72.5% and 76.1% of net profits, respectively. [GHL, 7/80]

On May 16, 1980, another three leases for approximately 360 acres of reserved mineral interests lands in Sonoma County were awarded. Geothermal Power Corporation, with a bid of 70.6% of net profits, was the high bidder for approximately 200 acres. MSR Public Power Agency (a consortium of

Modesto Irrigation District and the Cities of Santa Clara and Redding) was the high bidder for approximately 40 acres, with a bid of 26.1% of net profits. SMUD, with a bid of 55 percent of net profits, was the high bidder for approximately 120 acres. [GHL, 7/80]

Mono-Long Valley

BLM Lease Sale. The U.S. Bureau of Land Management (BLM) has announced the sale of leases on 18 parcels, totaling about 26,563 acres in the Mono-Long Valley KGRA. [GHL, 7/80]

7.2 SITE-SPECIFIC ACTIVITIES

ELECTRIC POWER PRODUCTION

The Geysers

PG&E

PG&E Unit 13. Unit 13 began generating full power at The Geysers Geothermal field on May 15, 1980. The 135 MWe plant receives steam from seven wells drilled by Aminoil USA. [GHL, 7/80]

PG&E Unit 15. A new iron catalyst-peroxide scrubber has been added to Unit 15 as of April 1980 to reduce 99% of H_2S emissions. Cost is $1 million (less than 3 mills/kwh). [GPM-3] The variance granted by the Air Pollution Control District, which has allowwed PG&E to exceed the limit of 100 gms H_2S/GMWh from Unit 15, expired May 1, 1980. [GEU, 3/80]

PG&E Unit 16. PG&E filed an application to construct Unit 16 and a 38-mile transmission line with Lake County in December 1979. The plant is scheduled to go on line in 1983. [GPM-2] PG&E is appealing a decision by the Air Pollution Control District which determined that Unit 16 will comply with clean air rules only if PG&E meets Unit 20 conditions.

PG&E Unit 17. CEC approved the 110 MWe unit in December 1979, fourteen months after the PG&E filing. Completion of the power plant is expected in early 1983. [GPM-2] Construction was to begin as soon as weather permits. [GEU, 3/80]

PG&E Unit 18. PG&E filed an Application for Certification (AFC) with the California Energy Commission (CEC) in December 1979. The unit will cost about $50 million, and generate 100 MWe. CEC expected to complete processing of the application within twelve months. [GPM-2]

PG&E Unit 20. As of March 1980, PG&E was preparing a twelve-month AFC for Unit 20. The plant is now to be sited in Sonoma County between Units 14 and 18. [GEU, 3/80]

NCPA

NCPA Unit 1. In March 1980, CEC granted preliminary approval to the 66 MWe NCPA Unit 1 in Cobb Valley. The application, with the unit now scheduled to operate in 1985, then entered the environmental review process. [GPM-3]

NCPA Unit 2. CEC approved construction of the 110 MWe NCPA Unit 2 in Sonoma County in March 1980. The plant could be operational by 1982. [GPM-3]

DWR

DWR Newfield/Cobb Valley. A court upheld the Lake County Board of Supervisors' denial of McCulloch Geothermal's drilling permit on environmental and planning grounds in December 1979. [GPM-2]

DWR Bottle Rock. The Lake County Board of Supervisors granted development permits to McCulloch Geothermal after it agreed to meet emissions requirements. [GEU, 3/80] McCulloch will use the Stretford hydrogen peroxide and EIC processes to control H_2S emissions. [GPM-3]

DWR South Geysers. An NOI (Notice of Intention) was submitted in October 1979. [GEU, 11/79]

SMUD

SMUD Unit 1. Aminoil USA submitted a plan of operation to the USGS in September 1979 for construction of well pads, drilling, and steam pipelines to the proposed power plant. USGS will prepare an EAR. [GPM-2]

SMUD submitted a 12 month AFC to the CEC in February 1980. The plant is in Sonoma County near PG&E Units 9 and 10. [GEU, 3/80]

Modesto Irrigation District/Shell Oil.

Site and unit unspecified. As of February 1980, MID had contracted for geothermal characterization of properties in Lake and Sonoma Counties, with an eye toward constructing a 55 MWe power plant. Estimated costs are $39.2 million to prove the field and $66 million to construct the plant. [GPM-3]

Imperial Valley

Heber

Southern California Edison (SCE). SCE informed DOE in December 1989 that it intended to apply for a loan guaranty for its proposed plant. [GPM-2]. Imperial County has granted production permits. [GEU, 3/80]

On May 15, 1980, Chevron U.S.A. Inc. and San Diego Gas and Electric Company (SDG&E) received approval from the California Water Resources Control Board for rights to use 50,000 acre feet and 20,000 acre feet per year, respectively, of water from the New River in Imperial County. After two years of consideration, the board found that use of water for underground injection to prevent subsidence and for electric power plant cooling is beneficial and in the public interest. The pollutants and high amount of total dissolved solids in the New River water preclude use for irrigation, domestic, municipal, and most industrial purposes. The Board found that the diversion of the project water will reduce the rate of inundation by the Salton Sea of littoral lands and delta wildlife habitat. It will also improve the overall quality of water in the New River below Clark Road.

SDG&E Demonstration Plant. In February 1980, the Public Utilities Commission (PUC) authorized SDG&E to participate in construction of a 50 MWe binary demonstration plant. Imperial County has granted production permits. [GEU, 3/80] Negotiations are underway with the U.S. Department of Energy. The proposed site at Heber is west of the East Mesa Geothermal field, in a 7,320-acre geothermal overlay zone estimated to be capable of supporting up to 500 MWe for 30 years. Project completion is scheduled for 1984. [GHL, 7/80] The plant should be on line by 1985. [GPM-3]

East Mesa

SDG&E/Magma. The 7 MWe plant is on line, with power being sold through the IID grid, as of March 1980. [GPM-3]

SGD&E/RGI. Republic Geothermal and Jacobs Engineering agreed in February 1980 to spend a total of $220 million to develop a 48 MWe geothermal plant. They are negotiating with SDG&E for electricity sales. [GPM-3]

Geothermal Component Test Facility (GCTF). The GCTF continues to be used to test and improve drilling equipment for geothermal operations. [PSD]

DOE/Lawrence Berkeley Laboratory (LBL) Pilot Plant. Barber-Nichols Engineering of Arvada, Colorado, is testing a 0.5 MWe pilot plant under the direction of the Lawrence Berkeley Laboratory. The objective of the plant is to determine whether the direct contact heat exchange process, which eliminates the heat-transfer surface areas on which scale can form in conventional geothermal heat exchangers, is economical. [GHL, 7/80]

Niland/Salton Sea

SCE/Union Oil. The Imperial County Planning Commission granted use permits to to construct a 10 MWe plant to test brine handling feasibility. The plant is to be completed in 1982. [GPM-3]

SDG&E/Magma. In May 1980, SDG&E and Magma Power Co. agreed to construct a 28 MWe and a 49 MWe geothermal power plant at the site of the SDG&E Niland Geothermal Loop Experimental Facility (GLEF). The letter of intent called for SDG&E to purchase power initially at 6.5 cents-kwh from

Magma's plant. [GRC, 5/80] Production permits have been granted by Imperial County. [GEU, 3/80]

Brawley

SCE/Union. The first steam plant to operate in the Imperial Valley started up on 6/21/80. [GHL 7/80]

Brawley Municipal Utility Consortium. A consortium of LADWP, Burbank, Pasadena, Anaheim, and IID is considering construction of a 45-50 MWe plant near Brawley. [GEU, 3/80]

Westmorland

SDG&E/MAPCO. MAPCO began drilling a production well in January 1980; 75% of the funding for this operation is covered by a loan guarantee.

International. SDG&E agreed in February 1980 to buy power generated from geothermal energy facilities in Cerro Prieto, Mexico, 30 miles south of Mexicali. [GPM-3; GRC, 3/80]

SDG&E and Mexico's Comision Federal de Electricidad (CFE) have taken part in cooperative operations since 1927. The two systems have connected a power line across the border east of San Ysidro. The utilities will operate briefly in parallel, but once the power link is stable, the Imperial Beach and San Ysidro substations will be disconnected from SDG&E's system and supplied by CFE power only. A 230 kilovolt power intertie, proposed for 1982, will prevent electric instabilities in the Mexican grid if a sudden power loss occurs in the SDG&E system. [GRC 3/80]

Other Areas

Coso

Naval Weapons Center (NWC)/CER. California Energy Company, Inc., of Santa Rosa, California, have signed a 25-year contract with the U.S. Navy to develop the geothermal energy resources at Coso. The agreement calls for production of 75 MWe of continuous power, providing electrical power not only to the NWC, but also to other naval installations in Southern California. The Navy will purchase electricity from California Energy Company at a cost below the commercial rate when the power plant comes on line in the mid-1980s. The first well for the project was to be drilled by June 1980. [S.G. Payne, Public Affairs Officer, NWC, China Lake] [GHL, 1/80] BLM has released a draft EIS projecting heavy demands on local water resources, and impacts on noise, water, and air quality from anticipated geothermal development. [GPM-3; GRC, 4/80]

DIRECT USE

Modoc County

Surprise Valley

CEC approved a plan by the Fort Bidwell Indian Reservation for direct use of geothermal energy for space heating, greenhouses, and aquaculture. [GPM-3]

Lassen County

Wendel-Amedee Cogeneration Power Plant. Geoproduct Corp., of Oakland is conducting feasibility studies for a 55 MWe geothermal/wood chip plant. The project is funded by the U.S. Department of Energy, the U.S. Forest Service, and the California Department of Water Resources. If successful, the power plant will be operational by 1984. (Ron Nicols, DWR project manager) [GPM-3]

DOE/Susanville Geothermal Project. The geothermal district heating plan for Susanville embraces 17 public buildings; waste heat will be used at nearby industrial parks. The city expects to save 275,000 barrels of oil per year. [IGCC] The project has now entered the construction phase. Plans call for drilling of two production wells and one injection well. The project is targeted for completion in the summer of 1981. [GRC 9/80]

Litchfield/Park of Commerce (Agribusiness). The Water and Power Resources Service (WPRS-formerly the Bureau of Reclamation) is drilling temperature observation holes 10 miles east of Susanville, near Litchfield. (Lyle Tomlin, WPRS) [GHL 1/80] Present plans include cascading partially cooled water from the California Correctional Center to the Park of Commerce for use in agribusiness projects. Susanville holds geothermal leases on 350 acres and through its developers is negotiating a 400-acre surface occupancy lease. The Carson Development Company of Sacramento will begin drilling the production wells about November 1, 1980, under a pending agreement with the City. (Phil Edwardes, Susanville Geothermal Principal Investigator) [GRC 9/80]

Susanville/HUD Block Grant. The City of Susanville has applied to the U.S. Department of Housing and Urban Development (HUD) to develop a heating system for 126 homes and a park of commerce. The City plans to retrofit the houses and set up the hot water distribution system, which will eventually tie into the DOE Susanville Geothermal Project system. Geothermal effluent will cascade from the home-heating project and the remaining usable heat will be used in the adjacent park of commerce. Businesses showing an interest in purchasing heat include a rabbit breeder and a greenhouse operator. [GRC 9/80]

Honey Lake Hydroponic Farms. The Honey Lake Hydroponic Farms Corporation operates 31 geothermally heated greenhouses about 28 miles east of Susanville. The complex is heated with 102°C (216°F) water pump from a nearby 630-foot (192-meter) geothermal well. [GHL, 1/80]

The Geysers

Middletown, Sonoma County. The town is considering water, swimming pool, and greenhouse heating at Verdant Vales School using bleed steam from The Geysers. [IGCC]

Imperial Valley

El Centro. The El Centro Community Center will be heated and cooled by geothermal energy, with financial assistance from DOE. The project may form the basis for expansion to other government and commerial buildings in the town. [GPM-3]

This project will involve drilling an 8,500-foot well capable of flowing 100 gpm of 121°C (250°F) fluid. The proposed production well will be located on land owned by the Imperial Irrigation District, about 4 miles north of the Heber KGRA and about 1/2 mile north of the community center. A 4,000-ft. injection well will be drilled in the same area. At the well site, a plant operating on a lithium bromide/water cycle will be constructed to produce chilled water from the geothermal fluid. [GHL, 7/80]

Brawley. Holly Sugar has received DOE assistance for a geothermal process heat system. [IGCC]

Coachella Valley.

Mecca. DOE is supporting expansion of a commercial prawn-raising operation, expected to be complete in late 1980. A third shallow well is being drilled by Aquafarms International, Mecca, California. The projected well depth is 200 feet. [IGCC]

Kelly Hot Springs. DOE is supporting a demonstration of direct use of geothermal energy for livestock feed production and a hog feed lot. The system is to be operating by the spring of 1982.

7.3 GOVERNMENTAL ACTIVITIES

FEDERAL ACTIVITIES

Energy Security Act of 1980 (ESA). The Energy Security Act of 1980 includes a synthesis of earlier "geothermal omnibus bills" as Title VI. ESA provides several new incentive programs for geothermal development: $750 million for forgiveable loans for exploration and reservoir confirmation drilling; liberalization of coverage in the Geothermal Loan Guaranty Program; and loans for feasiblity studies. ESA also mandates a program for using geothermal energy in federal buildings. A DOE study of the need for and feasibility of federal reservoir insurance was commissioned. Finally, the ceiling for exemption of geothermal power plants from the Public Utilities Regulatory Policies Act (PURPA) is raised from 30 MWe to 80 MWe.

Interagency Geothermal Coordinating Council. During 1979, the National Science Foundation withdrew from the IGCC and three new members were added representing the Departments of Defense, Commerce, and Housing and Urban Development. The Resource Panel and the Research and Technology Panel were abolished because their missions had been accomplished. A new Leasing and Permitting Panel was formed to evaluate legislation and regulation and make recommendations in matters involving federal land management and geothermal development. The Environmental Controls Panel will assist the Council in identifying means to ease environmental impediments to geothermal commercializaton. [IGCC]

Department of Energy (DOE)

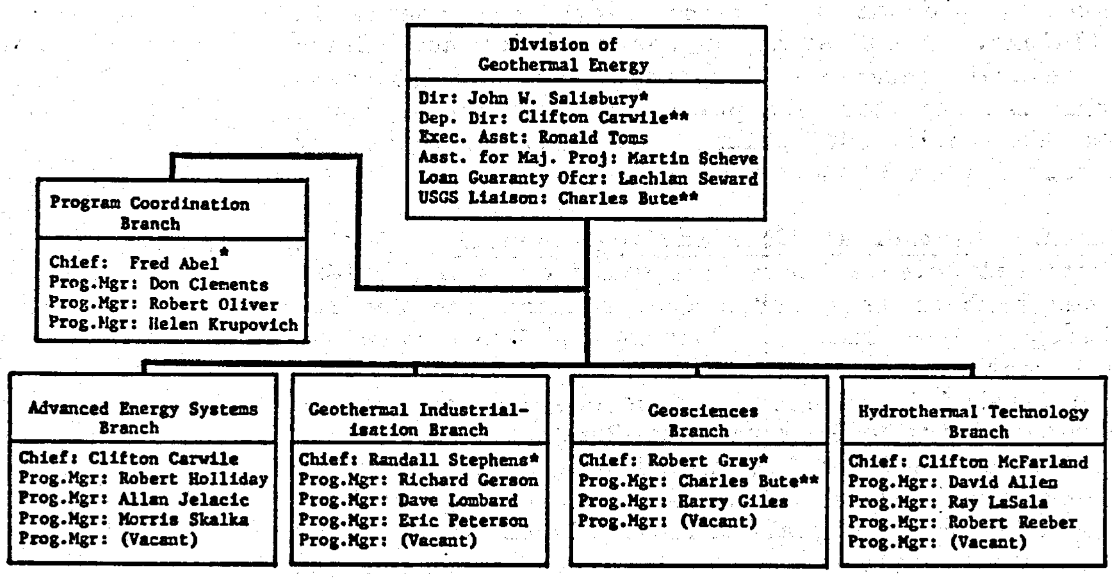
DOE Reorganization. In FY 1979, DOE shifted the responsibility for commercialization of hydrothermal resources from the Assistant Secretary for Energy Technology (ASET) to the Assistant Secretary for Resources Applications (ASRA). Early in FY 1980, as part of a major DOE reorganization, the office of ASET was abolished, and all ASET geothermal research and development programs were assigned to ASRA. DOE geothermal programs are now conducted under the direction of ASRA, with the exception of some basic research conducted by the DOE Office of Energy Research, and environmental research conducted by the Assistant Secretary for Environment. [PSD]

Geothermal Environmental Overview Project. GEOP, funded by DOE, is preparing socioeconomic studies at The Geysers, baseline data in the Imperial Valley, and subsurface environmental studies in both regions. [IGCC]

Geothermal Loan Guaranty Program. In FY 79, four loan guaranties were approved for a total of $43.4 million. Three of these apply to development in Imperial County.

FIGURE 7.3-1 Division of Geothermal Energy, Office of Renewable Resources, Assistant Secretary of Resources Applications

Figure 7.3-1. Division of Geothermal Energy, Office of Renewable Resources, Assistant Secretary of Resources Applications



Source: Department of Energy, October 5, 1980

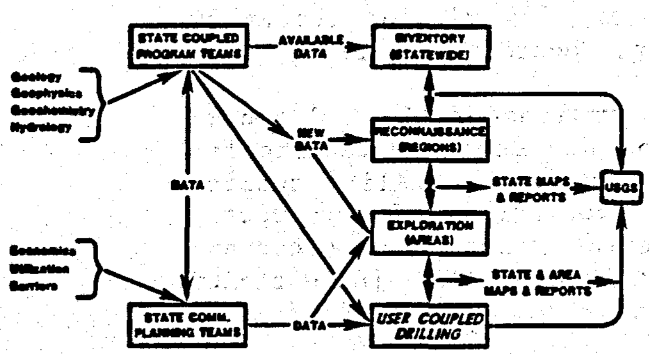
* Acting
**Dual Capacity

Republic Geothermal, Inc., obtained a guaranty of $9 million from the Bank of America for more exploration and testing in East Mesa. Westmorland Geothermal Associates was awarded $29.1 million by Bank of America to explore, test, and develop the resource in Westmorland. California-Utah (CU1) borrowed $1.8 milion from the Bank of Montreal (California) for resource exploration and testing in Brawley. [IGCC]

<u>User-Coupled Confirmation Drilling Program</u>. DOE has announced a $10 million program to provide federal cost sharing incentives (between 20 and 90%) for exploration, drilling, and testing activities undertaken to confirm hydrothermal reservoirs that can be developed for direct

heat applications. Figure 7.3-2 depicts the relationship between resources assessment activities of the State-Coupled Program and the User-Coupled Drilling Program.

Figure 7.3-2. Relationship Between the State-Coupled Program and the User-Coupled Program



Source: D. Foley, G. Brophy, L. Mink, R. Blacket, The State Coupled Program - A New Emphasis. Geothermal Resources Council Transactions, Vol. 4, September 1980.

The participation of State Resource Teams and State Commercialization Teams are also illustrated.

The program will be administered by Bob Gray, Chief of Reservoir Assessment for DOE's Division of Geothermal Resources. [DOE Announcement, 4/80]

<u>FY 81 Budget</u>. The initial DOE FY 81 budget for geothermal activities contained minor increases in overall funding to $152 million. Within this budget, relative emphasis was shifted from hydrothermal resources to technology development. [GRC, 3/80]

<u>US Geological Survey (USGS)</u>

<u>USGS FY 80 Budget</u>. The announced USGS FY 80 geothermal research budget was $9.9 million, almost $2 million less than FY 80. Efforts will emphasize resource inventory, exploration and assessment technology, resource characterization, geologic controls of subsurface effects, and geoenvironmental effects. [GRC 12/79]

<u>General Accounting Office</u>

GAO has been requested by Rep. Clausen to evaluate geothermal royalty and compensation policies, and to recommend improvements that better protect landowners. [GPM-3]

STATE GOVERNMENT

"Maximum Reasonable" Forecasts. A CEC staff survey for the Biennial Report states that the "maximum reasonable" potential for geothermal energy use, assuming implementation of R/D and economic incentives, is 2,108 MWe and 20 million therms of direct use by 1985, 3,650 MWe and 110 million therms by 1990, and 5,100 MWe and 220 million therms by 2000. [CEC, Nontraditional Energy Technologies, 3/80]

1981 Demand Forecasts. A committee of the CEC recommended that the Commission adopt new demand forecasts for the 1981 Biennial Report, based on recent utility submissions and changed energy market conditions. Noting recent plant deferrals, the report predicts that no new conventional powerplants need be built before 1992. [Electricity Tomorrow: 1980 Preliminary Report]

BLM Revenue Disbursement

AB 1905 was signed into law by Governor Brown on May 30, 1980, as Chapter 139 of the Public Resources Code. The new law channels BLM geothermal mineral lease revenues to a newly created Geothermal Resources Development Account as follows: (1) 40% to the counties of origin (in which the revenue was generated); (2) 30% to the California Energy Commission (CEC) for grants to local jurisdictions having geothermal resources; (3) 30% to the Renewable Resources Investment Fund administered by the California Resources Agency. (Ms. Syd Willard, CEC) [GRC, 7/80]

LOCAL GOVERNMENT

Lake County

Federal Lands. Lake County voted in November 1979 to assert authority in land-use decisions concerning geothermal development on private land with federal mineral rights; USGS intended to dispute this before the County Board of Supervisors. [GPM-2] In December 1979, the County claimed lead agency status under CEQA for privately owned lands with federal mineral rights. BLM and USGS contested this. [GPM-3]

Geothermal Department. Lake County will establish a new department to regulate geothermal energy development using funds from BLM revenues. [GHL 7/80]

DWR/Newfield. The Board of Supervisors denial of McCulloch Geothermal's drilling plans at Cobb Valley, on environmental and planning grounds, was upheld in court in December 1979. [GPM-2]

DWR/Bottle Rock Plant. The Planning Commission received over 700 letters of protest against their decision to deny full-field development for the Francisco-McCulloch DWR Bottle Rock Project. The campaign of support was backed by the Geothermal Association for Lake County. (Muriel Jordan, Geothermal Association for Lake County). [GRC 3/80] A use permit for full field development was issued after McCulloch agreed to meet environmental requirements. [GEU 3/80]

NCPA Unit 1. The Board of Supervisors decided to intervene in hearings for the NCPA Unit 1 to press for environmental controls. [GPM-2]

GKI/Boggs Mountain. The Board of Supervisors upheld an appeal by Geothermal Kinetics, Inc. to drill two wells on Boggs Mountain in the Boggs Mountain State Forest. [GRC 7/80]

GRIPS

Direct Use Project. GRIPS is investigating the possibility of direct use of geothermal energy in the rebuilding of a timber mill destroyed by fire. Applicatons combining district heating and fruit dehydration operations are being considered. [GPM-2]

Lake County Supervisor Raymond Morton was named Chairman of GRIPS in March 1980. [GPM-3]

Lompoc

The City Council, as of March 1980, was expected to approve financial cooperation with NCPA, through one of two non-profit coporations created to circumvent statutory limitations. [GPM-3]

Los Angeles County

The County has applied to the state for $45,550 to evaluate potential geothermal sites in the county. [GPM-3]

Inyo-Mono counties

In December 1979, the Inyo-Mono Association of Governmental Entities (IMAGE) requested CEC Funding of $63,000 for preparation of geothermal elements to the county general plan. [GPM-3]

7.4 INDUSTRY ACTIVITIES

RESERVOIR INSURANCE

Insurance Company of North America. Insurance Company of North America expects to issue its first reservoir insurance policies in early 1980. INA had obtained partial reinsurance, as well as two applicants. [GMP-2; GRC, 1/80]

ELECTRIC POWER RESEARCH INSTITUTE (EPRI) ANNUAL SURVEY

The 1980 EPRI survey of utility industry estimates of geothermal electricity shows small reductions from 1979 estimates of announced, planned, and probable geothermal generating plants in California and the U.S. as a whole, through 2000. However, growth is still projected to be rapid; California capacity is estimated to reach roughly 2,000 MWe by 2000, in a national capacity of roughly 10,000 MWe. [GRC]

APPENDICES

1. NEA INCENTIVES
2. CALIFORNIA LEGISLATION
3. STATE ORGANIZATIONS
4. GEOTHERMAL RESEARCH

APPENDIX I: FINANCIAL INCENTIVES PROVIDED UNDER THE NATIONAL ENERGY ACT

The National Energy Act of 1978 included a number of tax measures designed to stimulate geothermal exploration development. In addition, there are incentives which encourage the conversion from oil and gas to geothermal resource utilization.

The tax provisions are in three parts; (1) Depletion Allowances, (2) Intangible Drilling Cost, (3) Investment Tax Credits for business and residential applications, and (4) Deregulation of Methane. Each of these, in a different manner, affects the expected after-tax return on investment (ROI) from a geothermal venture. As the expected return increases, it will offset a portion of the risk* inherent to geothermal development,** and therefore increase the likelihood of participation by the investment community.

(1) Percentage Depletion Allowances

Percentage depletion allowances provide for a straight percentage reduction of gross income from the resource, based on its actual sales value. This essentially shelters a percentage of revenue from being taxed, thus reducing the net income base on which tax must be paid for the given period. Geothermal resources are subject to the federal depletion allowance limitations generally applicable to minerals. The amount started at 22% in 1978, declining to 15% in 1984 and the years following. There is no limit on the quantity of geothermal resource production on which percentage depletion can be taken, and a full allowance will be permitted without demonstrating actual resource depletability. These allowances will increase after-tax income, and subsequently ROI, because of the reduced tax base.

(2) Intangible Drilling Costs

Intangible drilling costs are those expenses that are not capitalized, normally comprised of labor, administration, and some exploration costs, and usually amount to 50-70% of total drilling costs. (Ref. - SRI)

The law allows all IDCs to be treated as expenses of the current period for federal income tax purposes, as is presently allowed for oil, natural gas, coal, and uranium. This increases the tax liability in later years when the cost would otherwise be deducted as capital depreciation. It is a tax deferral, not a tax reduction.

Geothermal deposits are now granted the same benefits available in the case of oil and gas wells. They are also subject to the same Internal Revenue Code provisions governing such deductions, specifically as

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* Risks of development have been discussed in Section 4.31.

** The risk will not actually diminish; instead, the attractiveness of taking the risk will increase with the availability of greater rewards.

they relate to 15% minimum tax, recapture, and at-risk rules.

The effect of a tax deferral such as this is an increase in the developers "return on investment" (ROI), because the present value of the after-tax income stream is raised.

(3) Investment Tax Credits

Investment tax credits (ITC) are a direct reduction of federal income tax liability by a percentage of the total amount of geothermal investment. Under the National Energy Act, a 10% credit is extended for geothermal capital investment, in addition to the normal ITC permitted. The credit is allowed on alternative energy property (expressly including geothermal) acquired or erected after September 30, 1978.* As currently written, it will expire on December 31, 1982. Used alone, or with other ITC's that may be available, the total may offset up to 100% of the liability in the taxable period, but it is not refundable. The effect of ITC's is to increase after-tax income and ROI for the developer. They will also reduce the front end investment necessary by reducing capital exposure and so attracting additonal investment. However, it should be noted that, under the National Energy Act, the business investment credit is not extended to public utility property, defined in part as "property used in the furnishing or sale of...electric energy...water...or steam...." Furthermore, the credit will be only 5% if the property is financed by tax-exempt industrial development bonds.

In addition, tax credits are included for residential geothermal use by homeowners or members of housing cooperatives. The allowable amount is 30% of the first $2,000 invested, and 20% of the next $8,000 for a maximum of $2,200. The credit is available through 1985, and may be carried forward to 1987 as it may not exceed the tax liability in any given year. The taxpayer may only claim a credit on his principal residence, and there is no requirement that he own the equipment.**

(4) Deregulation of Methane

The NEA provides for price deregulation of geopressured methane. The Act provided that additional energy costs will be borne by high volume industrial users rather than averaged among all consumers. In addition, natural gas from geopressure brine will be allowed a 10% depletion on wells begun between September 30, 1978, and January 1, 1984. Before and after that date, it will be treated as any other natural gas.***

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* This credit is available for depreciable equipment whose construction is completed between October 1, 1978 and December 31, 1982, and has at least a 3-year lifetime. The equipment must conform to standards promulgated by the Department of Energy.

** All equipment must meet DOE quality and performance standards.

*** A well producing both geopressured methane and hot water would be allowed a 10% depletion allowance for income from the methane (until 1984) and a 15-22% depletion allowance for income from the hot water.

Conversion Incentives

Included in the National Energy Act are provisions to encourage conversion from oil and natural gas usage to other forms of energy, geothermal among them. Equipment using oil and gas will no longer be allowed the base investment tax credit, and accelerated depreciation can now be taken on that equipment scheduled for early retirement.

Significant limitations have also been imposed on the use and installation of oil or natural gas boilers at power plants and major industrial facilities.* While exemptions for fuel cost, environment, and site limitations will be allowed, the burden is on the exemption applicant to prove the unavailability of alternative sources of energy.**

GENERAL REFERENCES

1. Randall Stephens, Geothermal Energy Legislation: The National Energy Act and New Proposals, Commercialization Conference, Geothermal Resources Council, November, 1978.

2. 1978 National Energy Act, Applications to Geothermal Development, Earl Warren Legal Institute, November 7, 1978.

3. James Forcier, Federal Geothermal Tax Incentives, California ERCDC, September 12, 1978.

4. Peter Maxfield, Income Taxation of Geothermal Resources, University of Wyoming, College of Law, 1977.

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* Those boilers with a designed heat rate capacity greater than 100 million Btu/hr.

** For instance, to obtain a cost exemption, one must show that other energy sources exceed the cost of imported oil, not domestic oil.

APPENDIX II: CALIFORNIA LEGISLATION RELEVANT TO GEOTHERMAL DEVELOPMENT

Session/ Bill Number	Description Relevant Code Sections	Status
1973-74 Session		
AB 1575	Creates California Energy Commission; specifies duties and authorities.	
	Sec. 25000-25960 Public Resources Code.	Enacted, Chapter 276, Statutes of 1974
1975-76 Session		
AB 3560	Creates geothermal resources task force, defines membership, mandates investigation of specified questions concerning geothermal development and regulation. Requires report by July 1, 1977.	
	Chapter 958, Statutes of 1976	Enacted, Chapter 958
1977-78 Session		
AB 566	Revises the amount of individual indemnity bonds which must be filed with the Oil and Gas Supervisor by any person involved in geothermal well operations.	
	Sec. 3204-3208.5, 3250-51, 3410, 3412, 3723.5, 3725.5, 3726, and 3728.5 of the Public Resources Code	Enacted, Chapter 112, 1977 Statutes
AB 791	Specifies that prospecting permits and leases for geothermal resources on state lands may be issued to the United States government or any agency thereof, and to state and local agencies.	
	Sec. 6905 of the Public Resources Code	Did not pass
AB 985	Revises the membership of the state task force designated for the study of the development of geothermal resources. Extends the due date for the report of the task force.	

	Sec. 1 and 5 of Chapter 958 of the Statutes of 1976.	Enacted, Chapter 249, 1977 Statutes
AB 2046	Revises exceptions from the requirement for alternative sites for proposed geothermal power plants and related facilities. Sec. 25004.1 and 25130, 25540 of the Public Resources Code.	Did not pass.
AB 2644	Revises the procedure for permit approval, filing of environmental impact reports, and procedure and time schedule in the processing and approval of notice of intent and application for certification with regards to geothermal development and exploratory projects. Assigns lead agency status for CEQA compliance. Sec. 65982.5 and 65960 et seq. of the Government Code. Sec. 3715.5 21065.5, 21090.1, 25101, 25102, 25115, 25120, 25133, 25540-25440.5 of the Public Resources Code. Sec. 782 and 2802 of the Public Utilities Code.	Enacted, Chapter 1271, 1978 Statutes
AB 3009	Designates Wilbur, Siegler, and Coso Hot Springs for protection from adverse effects of geothermal development. Requires the Secretary of the Resources Agency to recommend to the Legislature any additional hot springs needing protection. Sec. 3700.5-3700.7 to the Public Resources Code.	Did not pass.
AB 3476	Exempts electric power projects that utilize geothermal resources or solar energy from provisions of the California Environmental Quality Act. Establishes special treatment for coal-fired and nuclear power plants. Sec. 21084, 25512.5, 25524.26, and 25524.28 of the Public Resources Code.	

	Sec. 39620 et seq. of the Health and and Safety Code. Sec. 742 and 2802 of the Public Utilities Code.	Did not pass
AB 3707	Provides that exploratory, development, and production wells used in connection with geothermal resources development are not appurtenant facilities. Revises the amount of indemnity bonds that must be filed by persons engaged in geothermal drilling operations. Exempts geothermal drilling from requirements concerning hazardous wastes. Empowers PUC to curtail transmission of electricity from geothermal power plants.	
	Sec. 66732 of the Government Code. Sec. 25143 of the Health and Safety Code. Sec. 3725, 3725.5, 3728.5, and 25120 of the Public Resources Code. Sec. 782 and 2802 of the Public Utility Code.	Enacted, Chapter 1270, 1978 Statutes
SB 1005	Revises requirements for certification of siting of power plants in connection with the listing of alternative sites and report deadlines.	
	Sec. 25503, 25509-14, 25516, 25519, 25520.5, 25521.2 of the Public Resources Code.	Did not pass.
SB 1027	Revises procedures and terms for issuance of exploration permits for geothermal resources. Revises procedures and terms for leasing of lands containing geothermal resources.	
	Sec. 6902, 6904-5, 6908-13, 6916, 6918-9, 6921-22, 6924, 6925-1.2 of the Public Resource Code.	Enacted, Chapter 1139, 1978 Statutes
SB 1600	Provides for creation, organization, and operation of a non-profit organization to provide financial assistance to alternative energy business firms and to small businesses wishing to convert to alternative energy usage.	
	Sec. 32000 et seq. of the Financial Code.	Did not pass.
SB 1805	Removes requirement for filing of notice of intention for proposed construction of a thermal power plant less than 100 MWe	

	of a cogeneration plant less than 300 MWe of demonstration plants with site-specific energy sources. Requires State Energy Commission to rule on applications for certification of thermal power plants within twelve months after the filing of such applications.		
	Sec. 25134, 25503, 25524, and 25540.6	Enacted, Chapter 1010, 1978 Statutes.	
SB 1831	Requires the State Energy Resources Conservation and Development Commission to make grants to persons and entities to develop inventions and demonstrate alternative energy systems.		
	Sec. 25600 et seq. and 25620 et seq. of the Public Resources Code.		
SB 1832	Provides that no notice of intention shall be required regarding proposed construction of geothermal power plants and that the State Energy Commission shall issue within twelve months its final decision on the application for certification.		
	Sec. 25133 and 25540 of the Public Resources Code. Sec. 216 of the Public Utilities Code. Sec. 6353 of the Revenue and Taxation Code.	Did not pass	
Senate Constitutional Amendment #15	Permits Legislature to exempt from taxation all or any portion of property used as part of an alternative energy system.		
	Article XIII of the state constitution.	Rejected by voters, June 1978.	
Senate Joint Resolution #12	Legislature memorialized the Congress and President of the United States to provide immediate federal funding and assistance for the implementation of a hydrothermal binary cycle demonstration power plant in California.		

1979-80 Session

AB 2119	Requires the Oil and Gas Supervisor to grant permits for geothermal development only when it can be demonstrated that the development will not adversely affect nearby thermal springs. Requires the Department of Conservation to identify important thermal springs in California. Sec. 3800 et seq. of the Public Resources Code.	In committee.
AB 1333	Declares that it is in the public inerest to commit all means necessary to enable prompt and efficient development of alternative energy resources. Authorizes creation of energy resources promotion board. Sec. 26000 et seq. of the Public Resources Code.	In committee.
AB 1405	Creates the California Alternate Energy Source Financing Authority, specifying its organization, powers, and duties. Sec. 26000 et seq. of the Public Resources Code.	In committee.
AB 1905	Provides for the allocation of funds received by the state from geothermal leases and for the expansion of geothermal energy by providing funds to local governments for research, planning, and development. Sec. 3790 and 25820 of the Public Resources Code.	Passed Assembly; amended and postponed until 1980 by Senate.
SB 16	Provides for the creation, organization, and operation of a non-profit corporation which will provide financial assistance to qualified alternative energy business firms and to small businesses for purposes of implementation of alternative energy systems. Creates a State Energy Loan Fund in order to provide the necessary monetary aid.	

	Sec. 32000 et seq. of the Financial Code.	In committee.
SB 674	Amends the geothermal power plant certification procedure. Requires the State Energy Resources Conservation and Development Commission to keep confidential any proprietary information submitted to it except that concerning the chemical constraints and concentrations of geothermal fluids. Alters the procedure and time schedule for obtaining certification for a geothermal power plant. Sec. 25223, 25540-25440.2 of the Public Resources Code.	In committee.
SB 1205	Creates the California Energy Development Authority and prescribes the membership, powers, and duties of the board governing it. Requires the authority to administer designated programs to provide financial assistance for producers and consumers of alternative energy systems, and to encourage the installation of energy conservation measures. Creates a trust fund which would be appropriated to the authority to carry out its functions and purposes. Sec. 6117 and 27000 et seq. of the Public Resources Code.	July 19, 1979 failed passage in committee.
SB 1206	Authorizes the issuance of $500,000,000 in bonds to provide for long-term loans and loan guarantees to energy users to install alternative energy devices and conservation measures. Sec. 27000 et seq. of the Public Resources Code.	July 19, 1979 passage in committee
Assembly Constitutional Amendment #16	Authorizes the Legislature to provide for issuance of revenue bonds for financing the acquisition, construction, and installation of alternative energy source facilities. Article XVI of the state constitution.	In committee.

APPENDIX III: ORGANIZATIONS INVOLVED IN CALIFORNIA GEOTHERMAL COMMERCIALIZATION

STATE ENERGY AND ENVIRONMENTAL AGENCIES IN CALIFORNIA

AGENCY	DESCRIPTION OF DUTIES	CONTACTS
California Energy Commission 1111 Howe Avenue Sacramento, CA 95825 916-920-7361	See Energy Legislation Summary for Description of CEC Duties	Susan Brown Woody Ennis Dave Hill Justin Tiernan
Office of Planning & Research 1400 Tenth Street Sacramento, CA 95814 916-322-7797	Development of environmental and related land use goals and policies; evaluation of state plans and programs; and administration of federal grants-in-aid to ensure consistency with statewide environmental goals and policies.	
Secretary for Resources 1416 Ninth Street Sacramento, CA 95814 916-445-5656		
State Lands Commission 1807 13th Street Sacramento, CA 95814 916-322-7804	Overall responsibility for air pollution control in California and specific responsibility for controlling pollution from motor vehicles. Local air pollution control districts are concerned primarily with stationary pollution sources	
Department of Conservation 1416 Ninth St., Rm. 1320 Sacramento, CA 95814 916-323-1789	Assists in formation, organization, and operation of resource conservation districts. Advises districts as to plans and proposals relating to resource conservation activities.	Jan Denton
Geothermal Resources Board 1416 Ninth St., Rm. 1335 Sacramento, CA 95814 916-322-1080	Coordinates geothermal activities for the state. Activities include maintaining an inventory of geothermal resources, appeal of geothermal permits from the division of oil and gas, and implementation of the recommendations of the state task force on geothermal resources.	Jan Denton

Division of Mines and Geology 1416 Ninth St., Rm. 1335 Sacramento, CA 95814 916-445-5716	Collects, develops, and disseminates information about the geology of California. CEQA lead agency for exploring geothermal processing.	Roger Martin
Division of Oil & Gas 1416 Ninth St., Rm. 1316 Sacramento, CA 95814 916-445-1383	Regulates all in-state oil, gas, and geothermal wells. Also publishes monthly and annual reports on these wells.	Doug Stockton
Department of Fish and Game 1416 Ninth St., 12th Floor Sacramento, CA 95814 916-445-3531	Administers and enforces the state fish and game code. Activities include management of inland and marine fisheries, wildlife protection, and environmental data collection.	
Department of Forestry 1416 Ninth Street Sacramento,CA 95814 916-445-9920	Responsible for the protection and conservation of privately- and state-owned forest, brush, and grasslands. Activities include fire protection, reforestation, timber management, and a variety of other resource related actions.	
State Lands Commission 1807 13th Street Sacramento, CA 95814 916-322-7804	Jurisdiction over and management responsibility for state-owned sovereign and congressional grant lands. Handles related land leases, exchanges, and transactions; conducts oil, gas, geothermal, and other material leasing programs. Related activities involve boundaries and ownership determination, granted lands administration, and maintaining land information systems.	
Energy & Mineral Resource Development 100 Oceangate, Suite 300 Long Beach, California 90802 213-590-5205	Responsible for the development of energy and mineral resources on state lands. Issues leases for the development of these resources.	Don Everitts Eileen Burnett
Department of Parks & Recreation P. O.Box 2390 Sacramento,CA 95811 916-322-6087	Preserves choice pieces of landscape, preserves and restores representative examples of California's natural history, and provides recreational land for public use.	James Doyle
Native American Heritage Commission 1400 Tenth Street Sacramento, CA 95814 916-322-7791		Stephen M. Rios

Office of Historic Preservation 1220 K Street Mall Sacramento,CA 95811 916-322-8703		Nicholas Del Cioppo
State Water Resources Control Board 1416 Ninth Street Sacramento, CA 95814 916-445-2774	Concerned with state water rights, water quality, and water planning & research. Administers state responsibilities under the 1972 Federal Water Pollution Control Act.	Al Franks
Department of Water Resources 1416 Ninth Street, 4th Flr. Sacramento, CA 95814 916-323-4032	Formulates plans for water resource control, conservation protection, enhancement, and utilization. The department is authorized to construct and operate power generating facilities as part of the state water resources development system. This includes hydroelectric and other types of generating facilities, such as steam electric to provide power for pumping.	Lloyd Harvego Judy Warburg Tom Green
State Reclamation Board 1416 Ninth Street Sacramento, CA 95814 916-445-9454	Implements federal flood control in the central valley. Oversees control of central valley streams and local reclamation works.	
Solid Waste Management Board 1020 Ninth Street Suite 300 Sacramento,CA 95814 916-322-0744	Sets minimum standards for solid waste handling and disposal. Assists and monitors county implementation of solid waste management plans.	Michael Seaman Herbert Ywahiro John Boss

APPENDIX IV: GEOTHERMAL RESEARCH PROGRAMS IN CALIFORNIA

Institution	Activity
U.C. Berkeley	Legal and Institutional Considerations in the Commercialization of Geothermal Resources for Direct Uses. The object of this program will be to review and collect data on the market potential for small scale and direct-use applications for geothermal energy. An analysis and classification of the obstacles to commercialization, and an evaluation of policy issues for direct-use commercialization will be studied. The project directors are W. Michael Haneman, Agricultural Economics Dept., and John Nimmons, Earl Warren Legal Institute.
	Micro-earthquake and other seismic studies in geothermal exploration — Thomas McEvilly, Geology and Geophysics Dept.
	Electromagnetic, magnetotelluric, and d.c. resistivity, and other geophysical methods for geothermal exploration at Dixie Valley, Nevada, Mt. Hood, Washington, Cerro Prieto, Mexico, etc. -- H.F.Morrison, Engineering Geoscience Dept.
	Reservoir assessment and modeling studies — Paul Witherspoon, Materials Science and Engineering Dept.
Lawrence Berkeley Laboratory	A large effort in both the technical and non-technical aspects of geothermal development. LBL and UC Berkeley work in close liaison on most projects, including the technical projects listed in the previous paragraph. LBL's efforts are aimed at geothermal research, especially in the areas of exploration and reservoir technology, providing consulting services primarily for other government agencies, and in furnishing some management services.
	The Geothermal Resource and Reservoir Group manages the exploration and reservoir efforts, while the Mechanical Engineering and Energy Conversion Group manages the geothermal test facility at East Mesa, and is involved with heat exchanger research.
	Planning assistance in international activities and commercialization of geothermal resources in Region IX is being provided by Winifred Yen, Energy and Enviroment Division.

Lawrence Livermore Laboratory

Like LBL, Lawrence Livermore Laboratory has substantial research efforts in a number of geothermal areas.

The Imperial Valley Environmental Project was started in 1975, and is now in its final stages. Field measurements were completed in 1978 for air and water quality, ground subsidence, seismicity, ecosystems, and some socio-economic data. This data will probably be used to establish baseline information for this area.

The Geothermal Overview Project involves researching in several areas of geothermal development (e.g., enviromental issues). Workshops, etc., have been utilized to discuss issues and to raise possible solutions to problems encountered in each area investigated. Past projects have been undertaken at Roosevelt Hot Springs, Mono-Long Valley, and Coso Hot Springs. Present activities are centered in Hawaii, Oregon, New Mexico, and Nevada.

The Ecological Studies Program at The Geysers is studying the effects of pollutants on the vegetation, of sedimentation in the streams, of slope stability, and other geologic problems.

The ASCOT Program is developing a complex terrain model for meteorological and air quality problems in rough terrain.

A socio-economic program is also underway at The Geysers, and is a joint project with Lawrence Berkeley Laboratory.

In the area of environmental control technology, a state of the art report on an abatement system for H_2S and other airborne contaminants is being undertaken for the Imperial Valley area.

Technical studies have been performed in scale control and the removal of waterborne contaminants in geothermal fluids prior to reinjection and/or re-use.

An effort to develop a total flow machine was abandoned last year.

Jet Propulsion Laboratory	JPL has been working on a helical expander, a total flow device to be tested in Mexico. Support planning for direct-use commercialization is also being done.
U.C.Riverside	UCR is presently involved with a geothermal log interpretation project at East Mesa to study the lithology, petrology, and isotope geochemistry of the test well there. At the Salton Sea, UCR is studying ore formation in the geothermal field. In conjunction with LLL, they are doing some shallow temperature gradient measurements in the lake itself. They are also studying active seismic refraction in the lake. At Cerro Prieto (Mexico), under a subcontract from LBL, UCR is looking at the petrology and geochemistry of the geothermal wells. They are also looking at water/rock interactions to attempt to derive reservoir parameters. A guidebook to the geology and geothermics in the Imperial Valley is being published by Wilfred Elders. The Drylands Research Institute at the University has in the past done extensive work with economic, environmental, and political issues in geothermal development for Imperial County, and played an important part in developing Imperial County's Land Use Plan.
San Diego State	As part of a USGS extramural program, Bob McEwen (professor emeritus) has been involved with some geochemical testing at hot springs in Baja California.
Lassen College	Russell Rose of Lassen's Learning Resource Center has been instrumental in organizing several projects in conjunction with development efforts in Wendel-Amadee KGRA. Lassen has received support from the University of Nevada at Reno for agricultural and economic studies, and from Chico State in computer simulation (e.g., geothermal use in the dairy industry). Lassen is now negotiating with the Shaklee Corporation for land for a research site which will be used to study the agricultural applications of geothermal.
Sonoma State	Sonoma State has a number of its faculty involved in geothermal research activities. Richard Karas

(physics) has been doing some neutron activation studies for air pollution in The Geysers region. He is also coordinating a DOE-funded summer institute on geothermal energy for high school and junior college teachers.

William Wright (geology) has been conducting environmental studies for PG&E power plant sites, again in The Geysers.

David Fredickson (anthropology) has been investigating archaeological sites in Sonoma and Lake Counties, mainly for PG&E, Union Oil, and other geothermal suppliers, in The Geysers.

Chris Kjeldsen (geology) has an NSF-sponsored grant to study lichen as an indicator for pollutants from cooling towers. He is also analyzing soil and leaf samples to test for pollutants from cooling tower drift.

Long Beach State

Rosewitha Grannel has been working with gravity surveys in geothermal exploration.

Stanford

Stanford has had a large, diversified effort in geothermal research. The Stanford Geothermal Program (SGP) is a joint project between several engineering departments. It sponsors an annual meeting on geothermal reservoir engineering and technology.

Some of the individidual research efforts that are being undertaken are with reservoir simulation and well-testing analyses (Henry Ramey), radar tracers (Paul Kruger), seismic wave attenuation in active geothermal fields (Robert Kovocks), rock properties (Amos Nun), and a study of Italian geothermal fields (Frank Miller).

USC

Iraj Ershaghi has been involved with work supported by Los Alamos Laboratory at Cerro Prieto correlating geothermal well logs with similar data from oil field logs to look for similar evaluation techniques. He has also been looking at brine resistivity and rock resistivity at high temperatures, and doing some well logging for geologic formation evaluation.

Ken Chen has recently completed a study on low salinity fluids for possible contaminants, and methods for removing these contaminants from the environment as they leave the geothermal fluid. He has also done some fluid testing on wells from the East Mesa KGRA.

Chris Stone has been working with the NSF/ERDA/DOE since 1975 on a continuing analysis of the legal and institutional environment as it affects geothermal energy development through capital formation. He most recently has been working with DOE on revisions for the Geothermal Steam Act.

U.C. San Diego

Peter Cowhey is directing a project, Exploration of New Approaches to LDC Geothermal Development: Proposed Indonesian and Philippine Case Studies, which will undertake an assessment of geothermal energy development in these two LDCs, and will then determine the possible U.S. government role in these countries' geothermal planning and development. This project is being administered through the Earl Warren Legal Institute at UC Berkeley.

*Information current as of 12/79.