Hydrothermal Industrialization Electric-Power Systems Development

Final Report

March 1982

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J. Markiewicz
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1.0 INTRODUCTION

1.1 Purpose

The purpose of this report is to provide detailed and comprehensive site specific summaries of the status of geothermal electric power development and of industry's near and long term plans and prospects for future development. Since it is intended to be useful to equipment suppliers, financial institutions, utilities, and other private sector groups seeking reliable projections of the future growth of this industry, it has been structured to allow maximum use by a diverse audience.

1.2 Overview and Structure

In order to evaluate geothermal energy's contribution to the nation's total energy supply one must understand the nature of geothermal resources, their development process, who is developing them, historical trends, cost of development, current status, and market potential.

Geothermal energy is the internal heat of the earth and much of this energy is recoverable with current or near term technology. Three types of geothermal resources (hydrothermal, geopressured, and hot dry rock) are expected to be commercially exploited by the year 2000. Of these, only hydrothermal energy is technically and economically feasible for exploitation at this time. Therefore, for the purposes of this document, only hydrothermal geothermal resources will be addressed.

Section 2.0 provides a description of the nature of hydrothermal resources, their associated temperatures, geographic locations, and developable capacity.

The development of hydrothermal resources is a complicated and time consuming process. The establishment and confirmation of a reservoir and its subsequent development may require 10 years to complete. Section 2.1 examines in detail the parties involved in development, required activities and phases of development, regulatory and permitting requirements, environmental considerations, and time required to complete development activities.

Section 2.2 puts these activities in proper perspective by detailing development costs.

The development of hydrothermal resources assumes the existence of some type of an industrial infrastructure. To a very large extent, the geothermal industry has been developed by the integrated oil companies. Section 3.0 presents a profile of the geothermal industry by detailing the participants and their operating characteristics. Our analysis of the geothermal industry has been conducted prior to and after the inception of the Department of Energy. Land acquisition and well drilling activity were selected as the parameters for the analysis so that quantitative determinations could be undertaken.

In the United States, generation of electric power from hydrothermal resources currently stands at 925 Mwe. Most of this production (902 MWe) is located at The Geysers field in California, which is the world's largest geothermal power complex. Two 10 MWe plants located at

Brawley and East Mesa, California, and a 3 MWe plant at Puna, Hawaii account for the remainder. Developers and utilities involved in geothermal energy have proposed that an additional 2234 MWe be on-line by 1990. Most of these plants will be located in California, Hawaii, Nevada, and Utah. Section 4.0 details the current development status of geothermal energy in the U.S.

Numerous studies have been conducted to determine the market potential of hydrothermal energy. Due to varying assumptions, a wide range of estimates were generated. In order to adequately assess the future of hydrothermal energy, the Division of Geothermal Energy established a Task Force in 1980. The task force determined that future development will be determined by current project successes and a firm's criteria for investment. Section 5 discusses the composition of the Task Force, its objective, results achieved, and current role.

The remainder of this report is devoted to the presentation of detailed development information for 56 high temperature sites. This detailed information (presented in Appendix A) will assist private firms in evaluating market opportunities.

The detailed site-specific development information has been divided into the following three areas based upon the levels of activity:

- High Development - all sites that have power on line, announced plans for construction or where the levels of leasing and drilling activity indicate near-term development (Table 1).
- Moderate Development - all sites that have significant leasing or drilling activity but will not be developed in the near-term (Table 2).
- Low or No Development - all remaining sites (Table 3).

Within each of these sections the information is presented alphabetically by state and site. The information for each site is organized along the following outline.

- General summary about the site
- Site map
- Reservoir characteristics
- Leasing information
- Well drilling which includes number and type of wells drilled, temperature, depth, and flow rates, and wells drilled by year and company
- Permitting information
- Power plants -- operational and proposed.

Following the detailed site-specific information, a list of scheduled lease sales is presented in Appendix B.

TABLE 1

**Known Geothermal Resource Areas With
High Levels of Developmental Activity**

CALIFORNIA

1. Brawley
2. Coso Hot Springs
3. East Mesa
4. The Geysers
5. Heber
6. Mono-Long Valley
7. Salton Sea/Niland Area
8. Surprise Valley
9. Wendel-Amedee
10. Westmorland

HAWAII

11. Kapoho Reservoir (Puna)

IDAHO

12. Raft River

NEVADA

13. Beowawe
14. Brady Hot Springs
15. Desert Peak

NEW MEXICO

16. Valles Caldera (Baca)

OREGON

17. Crump's Hot Springs
18. Vale Hot Springs

UTAH

19. Roosevelt Hot Springs

TABLE 2

**Known Geothermal Resource Areas With
Moderate Levels of Developmental Activity**

CALIFORNIA

20. Lassen

IDAHO

21. Crane Creek/Cove Creek

NEVADA

- 22. Dixie Hot Springs
- 23. Humboldt House
- 24. San Emedio
- 25. Soda Lake Area
- 26. Steamboat Springs
- 27. Stillwater Area

OREGON

28. Alvord

UTAH

29. Cove Fort/Sulphurdale

TABLE 3

**Known Geothermal Resource Areas With
Low or No Developmental Activity**

ALASKA

- 30. Bailey Bay Hot Springs
- 31. Geyser Bight
- 32. Hot Springs Cove

ARIZONA

- 33. Power Ranches Inc. Wells

CALIFORNIA

- 34. Border
- 35. Clear Lake
- 36. Morgan Springs-Growler Springs
- 37. Randsburg
- 38. Sulphur Bank Mine

COLORADO

- 39. Paradise Hot Spring

HAWAII

- 40. Kamaile Homesteads

IDAHO

- 41. Big Creek Hot Springs

NEVADA

- 42. Baltazor Hot Springs
- 43. Fernley
- 44. Great Boiling Springs (Gerlach)
- 45. Hot Sulphur Springs
- 46. Kyle Hot Springs
- 47. Leach
- 48. Lee Hot Springs
- 49. Pinto Hot Springs
- 50. Sulphur Hot Springs

TABLE 3 (Cont'd)

**Known Geothermal Resource Areas With
Low or No Developmental Activity**

OREGON

- 51. Hot (Borax) Lake Area
- 52. Mickey Hot Springs
- 53. Neal Hot Springs
- 54. Newberry, Caldera
- 55. Trout Creek

WASHINGTON

- 56. Gamma Hot Springs

Numerous sources were used in the compilation of the site-specific information. The following list details sources and information obtained.

1. Lawrence Berkeley Laboratory Geothermal Data Base
 - Reservoir depth
 - Total dissolved solids
 - Leases issued after May 1980
 - Well drillings prior to 1978 and October 1980 to present.
2. United States Geological Survey
 - a) Circular 790
 - Reservoir temperature
 - Estimated Electric Energy Potential.
 - b) Conservation Division, Geothermal Applications and Lease Records System
 - All leases issued prior to May 1980.
3. Geothermal Progress Monitor
 - Development status.
4. "Site Specific Analysis of Geothermal Development-Data Files of Prospective Sites," Williams, Cohen, Pfundstein, and Pond
 - Site location and characteristics.
5. MITRE Corporation Drilling File
 - Wells drilled from 1978 through September 1980.
6. Imperial County Geothermal Development Quarterly Reports
 - Regulatory and Permitting information for Salton Sea, Brawley, Heber, and East Mesa
 - Development barriers identified at East Mesa.
7. "Data Base on all Federal Non Competitive Geothermal Lease Applications," Appendix D, Area and site specific data on Geothermal prospect areas, Beeland and Schuman, August 1980
 - Regulatory and Permitting information except for Imperial County
8. Oregon Institute of Technology, Geo-Heat Utilization Center
 - Development barriers identified at Alvord, Crump's H.S., Hot Lake Area, Mickey H.S., Neal H.S., Newberry Caldera, Trout Creek Area, and Vale H.S.
9. EER Survey of Developers
 - Development barriers identified at Salton Sea, Surprise Valley, Heber, Steamboat Springs, Brawley, Westmorland, and San Emedio.

2.0 HYDROTHERMAL RESOURCE DESCRIPTION

Hydrothermal resources are underground accumulations of hot water or steam with temperatures ranging up to about 350°C (660°F). Water heated by contact with deep hot rock formations moves through fissures, faults, and fractures to porous reservoir rocks at shallower depths, within reach of modern drilling technology. Hydrothermal fluids may contain dissolved gases (such as carbon dioxide and hydrogen sulfide) and dissolved minerals. Some hydrothermal fluids are highly corrosive; others may cause scale to accumulate in porous rock formations, in well bores, or on the surfaces of man made equipment.

Hydrothermal resources are classified as either vapor dominated (dry steam) or liquid dominated (wet steam/hot water). Vapor dominated systems are found in subsurface reservoirs, where water reaches boiling temperatures at depths below the prevailing water table, and in pore spaces within the reservoir rock. Vapor moves upward and is heated further by the surrounding rock. A zone of cooler, near-surface rock may induce condensation, with a portion of the condensed water moving downward to be vaporized again. In liquid dominated systems, ground water absorbs heat from molten or hot rock and carries it toward the earth's surface.

Vapor dominated systems are the most easily developed, but they constitute only a small fraction of the nation's hydrothermal resources. Liquid dominated systems at temperatures suitable for producing electric power (above 150°C) are estimated to be 10-20 times more numerous than dry steam resources. Most of the known United States hydrothermal resources hot enough to generate electric power are located in the West.

The USGS (Circular 790) has identified 53 Known Geothermal Resource Areas (KGRAs) suitable for generation of electric power. The reservoirs underlying KGRAs are primarily liquid dominated. Their thermal energy content can be converted to electric power by means of flash steam or binary energy conversion systems, depending on the characteristics of the hydrothermal fluid. The prospects identified in Circular 790 could supply about 24,000 MWe of capacity for a 30-year period. About half of the known hydrothermal electric power resources are located in California; most of the rest are in New Mexico, Nevada, Oregon, Utah, Idaho and Hawaii.

Six of the known locations appear large enough to support production at levels of more than 1,000 MWe each for 30 years. These are the Salton Sea area, California; Valles Caldera (Baca Ranch), New Mexico; Mono-Long Valley, California; Westmorland, California; the Geysers, California; and Lake City-Suprise Valley, California.

The USGS anticipates the discovery of additional high temperature reservoirs that will be identified during the next 20 years. Recent rates of discovery support the expectation. For example, the Westmorland reservoir, probably the fourth largest known reservoir in the U.S., was discovered between 1975 and 1979, and is scheduled to begin producing power in 1985. Many other high quality reservoirs, including Desert Peak and Humboldt House, have been discovered during the last four years. The USGS has estimated that the potential energy available from undiscovered high temperature reservoirs may be 5 times as great as that available from the presently known reservoirs; thus the

total hydrothermal electric power capacity developable with near-term technology is on the order of 144,000 MWe.

In turn, these high temperature reservoirs represent but a small segment of the total resource base. As future technical advances make it economically possible to generate electric power from the more abundant lower temperature resources, the potential capacity for hydrothermal electric power production will multiply.

2.1 Development of Hydrothermal Resources

This section examines in detail the steps for developing a hydrothermal site and constructing an electric power plant. Figure 1 illustrates the time required for each activity, the key regulatory milestones, and the sequence of activities required in the development of a typical first 50 MWe plant on a Federal lease*. The principal commercial participants are the field developers (exploration and drilling companies) and the utility companies.

The development sequence may be divided into four major phases:

- o Pre-Lease Exploration
- o Leasing
- o Post Lease Exploration and Reservoir Characterization
- o Full Field Development and Plant Design/Construction

The following paragraphs discuss the tasks involved in each phase, regulatory/permitting requirements, environmental considerations, and the time required for completion of each phase.

2.1.1 Pre-Lease Exploration

The exploration for geothermal resources is centered on locating a field which is capable of supporting electric power generation at a feasible cost. The factors which determine the suitability of a given reservoir are its temperature, depth, fluid productivity, fluid quantity, and productive lifetime. After deciding to pursue hydrothermal electric power development, a development company initiates pre-lease exploration activities. The first step is a review of the current literature to identify prospective areas; features are sought in the geology, hydrology, and surface characteristics indicative of geothermal potential. These initial studies may also include broad geologic assessments and the analysis of available aerial photography or imagery. Airborne magnetic surveys may also be flown over promising areas. This initial casual use exploration causes little or no surface disturbances, and require no permits or operations review.

Should these initial results prove encouraging the developer proceeds by conducting more intensive exploration operations such as geophysical surveys, placing of sensors and the drilling of shallow (150 meters) temperature holes. The developer is required to submit a Notice of Intent (NOI) to conduct the aforementioned activities to the appropriate surface management agency. The NOI lists the location of

* Section 2.1.5 describes the development of hydrothermal energy on non-federal land.

FIGURE 1

HYDROTHERMAL ELECTRIC POWER USE INDUSTRIALIZATION SEQUENCE (ARCHETYPE)
(FIRST PLANT-50MWe-FEDERAL LAND)

Source: Analysis of Requirements for Accelerating the Development of Geothermal Energy Resources in California

the site, description of the proposed activities and the dates during which the activity will be carried out. The surface management agency will either deny the application or approve it. The approval may be accompanied by a set of operational stipulations. Operational stipulations may include the restriction of specific activities, limitation on the timing of activities and rehabilitation requirements. The review of the NOI represents the first environmental assessment the specific lands will receive. The developer should supply a site map, high altitude color infrared photographs as well as black and white, low altitude, stereo-paired photographs of the proposed area of activity. This information will facilitate the review of the NOI.

2.1.2 Leasing

The importance of land costs in the overall expenditure for exploration should be noted. Fairly early in the evaluation of lands, control of the geothermal interests must be secured. Without such control, the property and the investment in exploration will be lost to another party. As the developer applies for a noncompetitive lease or a KGRA is scheduled for a competitive lease sale, the appropriate surface management agency (BLM) must conduct an Environmental Analysis Report (EAR). The EAR is an analysis of the area to be leased in terms of the environmental, socio-economic, and land use impacts of the sale. The surface management agency will conduct the major part of the EAR; geological and hydrological information may come from other federal and state agencies. Areas that are deemed to have significant value will require withdrawal or special or restricted use to ensure their proper maintenance. The surface management agency will assume the responsibility of putting forth the special lease stipulations in the lease sale and will have partial management responsibility during post lease operations. Basic conditions of lease issuances concern acreage limitations, rentals, royalties, surety bonds, pollution control, and other similar particulars. On Federal lands the preparation and completion of the EAR and the issuance of a lease may take up to 30 months.

2.1.3 Post Lease Exploration and Reservoir Confirmation

After a lease has been awarded, the lessee must submit a plan of operations to the USGS for approval. For each plan of operation the USGS prepares an Environmental Analysis describing the ecological and environmental considerations of the proposed activities. The developer continues exploration activities such as gravity and magnetotelluric surveys, active and passive seismic measurements, and the drilling of shallow heat flow holes. It is at this point in time that deep exploratory well drilling is undertaken. The developer must submit an Application for Permit to Drill (APD) to the USGS. All well drilling, alterations, and abandonment methods must be approved by the area USGS supervisor.

Deep well drilling operations require the construction of access roads. Approximately 2 to 3 days must be spent on road building for each mile to be constructed. Heavy duty drilling operations will require the construction of drilling pads, which will require 3 to 4 days work to complete for each drill site. Near the drilling pad a mud

sump must be constructed for the temporary storage of drilling muds and for the possible temporary storage of geothermal resource effluent produced during testing. Due to the toxic nature of certain mud additives the sumps are subject to permeability requirements.

After the completion of the well, the productive potential of the reservoir must be tested. The nature of the resource will determine the type of testing required. Testing involves the discharge of gases into the atmosphere, and in the case of a liquid resource there will also be a liquid discharge into the sump, injection well or other designated areas. Determination of the well's productive capacity will lead to two possible courses of action:

- 1) if the resource testing is considered successful, the well will be shut down, pending further drilling leading to the development of a producing geothermal field. At that time, the well would be reopened as part of the production unit.
- 2) if the testing proves unsuccessful, the well may be used for other geothermal investigations or for injection. After further investigations are completed the well will be cemented and abandoned.

If the characterization activities prove successful, the developer will initiate preliminary negotiations with utility companies as potential customers for electric power. Post lease exploratory and characterization activities will require approximately 36 months to complete.

2.1.4 Full Field Development and Plant Design/Construction

The presence of a hydrothermal resource suitable for electric power generation, having been established will initiate the study of power plant design options by the developer and utility. Plant design for a geothermal reservoir is selected according to the character of its fluid. For liquid-dominated reservoirs, plant design is dictated by fluid temperature, mineral content and the quantity of dissolved non-condensable gases. Local water supply, meteorological conditions and environmental sensitivities also affect plant selection. Three basic design options are available for liquid dominated reservoirs: flashed steam, binary fluid and total flow systems.

• Flashed-Steam

Geothermal fluid may arrive at the wellhead as a two-phase fluid due to downhole flashing, which occurs as a result of decreasing pressure. Such fluid can be utilized in a "flashed-steam" power cycle wherein the vapor phase is separated and used to drive the turbine. The remaining brine fraction may be either discarded or flashed to produce lower-pressure steam to supplement the separated steam. Multi-stage flashed-steam power plants (beyond the dual-flash configuration) are technically feasible but economically unattractive at the present time. Flashed-steam technology is generally suitable only for high-temperature resource fluids and a small portion of moderate-temperature fluids. The presence of dissolved and suspended solids and noncondensable gases in the

fluid can pose problems such as corrosion and erosion for turbines and condensing equipment.

- Binary

A hydrothermal binary cycle transfers heat from the geothermal fluid to a secondary fluid which serves as the working fluid. The simplest configuration uses single-phase geothermal fluid as the heat source. Increasingly complex arrangements can be designed where separated and/or flashed steam is used to either heat the working fluid or run a second turbine-generator. The binary cycle can achieve relatively high utilization efficiencies with moderate-temperature resources. Other benefits include isolation of the turbine from the corrosion, erosion, and scaling of the geothermal fluid. The development of direct-contact heat exchangers promises to eliminate the serious scaling problems associated with binary cycle surface-contact heat exchangers.

- Total-Flow

The total flow cycle energy conversion concept for hydrothermal power systems recognizes that a direct expansion of geothermal fluid from wellhead to sink conditions has the potential for conversion of the greatest fraction of the available energy to useful work. A total flow system admits full two-phase flow from the well directly into the expander (prime mover). This process avoids the energy losses associated with the flashing/separation process in flashed-steam cycles and with the heat transfer process in binary cycles. Although no geothermal total flow devices are commercially available at this time, laboratory and field testing of two such devices is in progress.

Once a design has been selected the developing utility files a Production Plan. This review process establishes the need for the plant and the environmental acceptability of the site and plant design.

As industry proceeds with full field development, new or extended roads will be constructed, additional wells will be drilled requiring new drilling pads, mud sumps and storage areas. Surface structures such as pipelines will be built to collect and deliver steam to the power plant. Geothermal fluids are brought to the surface via the production wells. After the heat is extracted, the fluids, now somewhat cooler must be disposed of. One method, particularly suitable for geothermal brines is to return the fluid, under pump pressure or gravity to the reservoir.

Electric power development for an initial 50 MWe plant will require additional production and injection wells, pipelines, and the generating facility itself. The construction of the power plant proceeds in tandem with the drilling of production wells. Plant construction and production well drilling require approximately 24 months to complete, and subsequent plant start up and testing take about six months more.

2.1.5 Development on Non-Federal Lands

The previous subsections have discussed the development of geothermal resources on federally held lands. Although most of the activities discussed also pertain when the land is held by a state government or a private entity, some differences do exist. State laws about geothermal resources differ as to how the resource is defined and categorized. Different agencies within the various states are responsible for the supervision of geothermal development, and the specific regulatory and leasing procedures vary from state to state.

The federal government and the State of California have developed different definitions of geothermal resources. The most important distinction between the two involves the consideration of geothermal brine. While the California definition distinguishes between the fluid medium and the energy minerals contained in it, the federal definition includes the fluid medium as part of the geothermal resource. The major implication of this difference is that under the California definition, a developer is subjected to water use statutes if untreated produced fluids are to be utilized for irrigation or other purposes. Most of the other states with geothermal resources have based their definitions of geothermal resources on the federal and/or the California definitions.

Access to a geothermal resource is largely determined by the legal nature of the resource as categorized by the state in which the resource is located. Depending on the state involved, a geothermal resource may be considered to be a water resource, a mineral resource, a gas resource, or a unique form of resource. Most states and the federal government do not assign geothermal resources to any category of resource.

In general, state agencies have jurisdiction over state-held lands, but in some cases local governments have jurisdiction over development of privately-held lands. At the state level, different agencies are charged with jurisdiction over the development of geothermal resources in the various states. For example, in Arizona and Colorado geothermal resources are in the jurisdiction of the Oil and Gas Conservation Board, in Washington and Alaska they are within the purview of the Department of Natural Resources, and in Texas they are managed by the School Land Board and the Texas Railroad Commission.

Regardless of which agency is assigned the tasks of overseeing geothermal development, the goals of regulation are largely consistent from state to state. The states desire that geothermal resources be exploited in a manner such that the environment is protected and the resource is not wasted. Additionally, the states attempt to promote the development of a vigorous and competitive industry. For these purposes the states with geothermal resources require that permits be obtained for well drilling, conversion, capping, or abandonment; and they require that geothermal developers submit reports on well drilling and logging. The states also regulate the disposal/utilization of spent geothermal fluids and enforce compliance with the relevant air and water pollution control laws. The states require the posting of performance bonds, and some states require that developers hold liability insurance.

Leases to state lands containing geothermal resource potential may be granted through either competitive or non-competitive bidding procedures. In most states both procedures are employed, but in Montana and Wyoming, the law requires competitive bidding for all leases to state lands for geothermal development.

Some states set minimum and/or maximum limits on the acreage that an individual entity is allowed to lease for geothermal exploration or development. Although the states are legitimately concerned with preventing monopolization of geothermal resources, in some cases, these limitations may serve to inhibit development by fragmenting the resource to the extent that large-scale development is impractical.

2.2 Development Costs

The existence of confirmed geothermal resources and the technology to use them do not constitute sufficient motivation for commercial development. Development costs are a major factor in geothermal investment decisions. These costs may be divided into three major areas:

- Exploration and Leasing
- Deep Well Drilling
- Plant Construction

In addition to exploration costs, there are leasing costs which include application costs, fees and rentals, and if required, environmental studies and competitive bonus bids. Table 4 presents capitalized costs associated with exploration and leasing.

Deep well drilling costs depend on local geologic conditions. In an area of igneous geology, drilling costs are significantly higher, than those in areas with sedimentary geology as shown in Figure 2. At a depth of 8,000 feet for example, a well drilled in sedimentary region would cost approximately \$500,000; one drilled in igneous region would cost \$1,500,000. Such significant differences in cost due to geology have a definite influence on hydrothermal development decisions.

Plant construction costs are the largest of the three major elements of the costs of development. Table 5 illustrates the capital cost of a dual flash steam plant (50 MWe) designed for a temperature of 240°C. Table 6 gives the capital cost of 50 MWe binary plants designed for three different resource temperatures.

TABLE 4

EXPLORATION AND LEASING COSTS
(CAPITALIZED)

ITEM	1980 COST
- Land Lease and Rights	\$112,400
- Pre Lease Surface Exploration (NOI, Permits, Geochemistry, Geology)	56,200
- Post Lease Surface Exploration	16,860
- Thermal Gradient Wells, Drilling Permits, Well Logs	44,960
- Detailed Exploration	84,300
TOTAL	<u>314,720</u>

Source: Cassel, Edelstein, Blair, and Amundsen (Oct., 1979), Geothermal Investment and Policy Analysis with Evaluation of California and Utah Resource Areas, prepared for U.S. Department of Energy. Costs have been modified to reflect 1980 dollars.

FIGURE 2

HYDROTHERMAL WELL COSTS
(1980 Dollars)

Source: Cassel, Edelstein, Blair, and Amundsen (Oct., 1979), Geothermal Investment and Policy Analysis with Evaluation of California and Utah Resource Areas, prepared for U.S. Department of Energy.

TABLE 5

CAPITAL COST OF A DUAL FLASH STEAM PLANT (50 MWe)
 (1980 \$)
 240° C (464°), NEGLIGIBLE TDS AND DISSOLVED NON-CONDENSIBLES

<u>ITEM</u>	<u>EQUIPMENT</u>	<u>LABOR</u>	<u>TOTAL</u>
<u>Land and Land Rights</u>			100,000
<u>Structures and Improvements</u>			400,000
Plant Site Preparation			400,000
Foundations and Structures			<u>2,300,000</u>
Subtotal			<u>2,700,000</u>
<u>Major Equipment</u>			
Turbine Generator	7,000,000		
Condensers	1,450,000		
Cooling Water Piping	860,000		
Cooling Tower and Basin			
Cooling Water Pumps	550,000		
Vacuum Compressors	<u>200,000</u>		
Subtotal	<u>10,060,000</u>		
<u>Construction and Small Equipment</u>			
Crane	287,000		
Electrical & Switchgear	2,729,900		
Instrumentation & Controls	1,279,700		
Steam & Brine Piping	300,000		
Valves	760,500		
Secondary Flash Tanks	450,000		
Misc. Tanks & Piping	400,000		
Fire Protection System	112,500		
Spare Parts & Tools	250,000		
Misc. Mechanical Equipment	1,400,000		
Reinjection Pumps	190,000		
Reinjection Filters	<u>610,000</u>		
Subtotal	<u>8,770,000</u>		
TOTAL EQUIPMENT	18,830,000		
Sales Tax @ 5%	941,500		
Labor & OH @ 30% of Equipment		5,931,400	
Total Direct Cost, Excl. Land Rights			30,710,700
Contractor Markup & Constr. Mgt. (15%)			4,606,600
Contingency (10%)			3,531,700
Design			2,500,000
Plant Startup			<u>300,000</u>
TOTAL			42,749,000 (\$826/KWe net)

Source: EG&G

TABLE 6
BINARY PLANT CAPITAL COST 50 MWe NET

ITEM	290°F* (1980 \$)	360°F* (1980 \$)	500°F* (1980 \$)
<u>Land and Land Rights</u>	100,000	100,000	100,000
<u>Structures and Improvements</u>			
Plant Site Preparation	400,000	400,000	400,000
Foundations and Structures	2,300,000	2,300,000	2,300,000
<u>Major Equipment</u>			
Turbine Generator	6,143,000	4,740,000	4,120,000
Condensers	5,736,000	2,619,000	2,236,000
Cooling Water Piping	1,401,000	1,242,000	774,900
Cooling Tower and Basin	5,206,000	2,377,000	1,939,300
Cooling Water Pumps	1,006,500	823,600	361,900
Heat Exchangers	5,380,000	4,882,000	3,313,000
Condensate Tanks	348,900	204,300	115,700
<u>Construction and Small Equipment</u>			
Crane	287,000	287,000	287,000
Electrical and Switchgear	2,729,900	2,729,900	2,729,900
Instrumentation and Controls	1,599,600	2,599,600	1,599,600
Working Fluid Piping and Valves	2,318,000	1,176,800	836,900
Brine Piping and Valves	530,000	327,100	182,100
Miscellaneous Tanks and Piping	400,000	400,000	400,000
Fire Protection System	225,000	225,000	225,000
Miscellaneous Mechanical Equipment	1,400,000	1,400,000	1,400,000
Spare Parts and Tools	250,000	250,000	250,000
Reinjection Pumps	450,000	319,800	142,200
Reinjection Filters	2,671,000	1,200,000	447,300
Feed Pumps	898,600	526,000	298,100
Sales Tax @ 5%	1,949,000	1,366,500	1,082,900
Labor & Labor OH, 30% of Equipment	12,278,900	8,608,800	6,822,600
Total Direct Cost, Excl Land Rights	55,908,400	40,004,900	32,264,400
Contractor Markup and Cost Mgt. (15%)	8,386,300	6,007,400	4,839,700
Contingency (10%)	6,429,500	4,600,600	3,710,400
Design	2,500,000	2,500,000	2,500,000
Plant Startup	300,000	300,000	300,000
TOTAL	73,524,200	53,512,900	43,714,500

* Indicates Well Head Temperature

Source: EG&G

3.0 INDUSTRIAL INFRASTRUCTURE

The two major participants in the development of geothermal energy are the field developer and the electric utilities, and to understand geothermal development it is necessary to know their particular roles. The development companies can be divided into five major categories:

1. Integrated Oil Companies
2. Oil Producers
3. Large Industrial Firms
4. Independent Geothermal Firms
5. Government/Institutions

3.1 Participants and Roles

To a very large extent the geothermal industry has been dominated by the integrated oil companies as evidenced by their levels of land acquisition and well drilling. Their entrance into the geothermal arena was a result of their strong financial position and unsurpassed technical ability, as well as a continuation of their overall diversification philosophy. In the oil industry production is the most profitable segment. Geothermal development, in which these firms function as producers, was therefore a logical outgrowth and an attractive alternative. Long lead times for development have not deterred these firms since initial losses can be used to offset cash flows from other investments. Major firms involved in geothermal development include: Union, Chevron, Phillips, Getty, Shell, Sunedco, Occidental, and Gulf.

In comparison to the integrated oil companies the oil producers tend to be thought of as small. This smallness is due to a lack of vertical integration and not financial strength. The number of these firms making geothermal development a part of their overall corporate picture has been relatively small but enactment of incentives aimed at these firms could spur their additional involvement. Oil producing firms currently involved in geothermal development include McCulloch Oil Resources, Thermal Power (part of Natomas), Hunt Oil, and MAPCO.

Large industrial firms are another participant in the development of geothermal resources. Many of these firms, particularly those in electricity intensive metals, paper, and cement industries have already begun their search for new sources of power. A substantial number of these firms have traditionally sought to generate their own electricity and have entered the field of resource extraction. These firms have entered into the geothermal area for a number of reasons. Diversification into other areas has become commonplace and energy is viewed as a lucrative area for expansion. In addition, any excess capacity that is developed can be sold to a utility on a non-regulated basis. Moreover, a significant number of these firms are located in geothermal resource areas of the western United States. Some have formed joint ventures with utilities and resource development companies. Major firms involved are Amax Exploration, Barnwell, Aminoil (subsidiary of R.J. Reynolds Industry, Inc.) Gedco (Part of Barnwell Industries), and Anadarko (wholly owned subsidiary of Panhandle Eastern).

The geothermal independents are a unique entity. Some of them have never drilled a well, and many have been content to lease poten-

tial areas and wait for an experienced firm to confirm the prospects's potential. Many of these firms have sold their interests to the large oil companies and started the process all over again. Magma has been the significant firm of this type to aggressively explore for geothermal resources, evidenced by its involvement at the Geysers. Other major firms include Republic Geothermal, Geothermal Kinetics, MCR* (formerly McCulloch Geothermal Corporation), Thermogencis, and Geothermal Resources International.

The final entity to undertake exploratory activities has been the government/institutions. USGS has drilled several wells throughout the western United States. Additionally DOE through various contractors has sought to locate and explore geothermal areas. Specifically, DOE has been involved in the development of the geothermal resource at Raft River, Idaho. Several universities have also undertaken drilling operations (usually under government funding) most notably the University of Hawaii and the University of Utah. This type of activity by government/institutions however is only transitory and is not expected to contribute significantly to the overall drilling activity.

The other major participant in the development of geothermal energy is the electric utility. Many factors have contributed to the utilities involvement in geothermal energy. The phase out of natural gas as a boiler fuel and continual challenges from environmentalists over coal and nuclear projects have forced utilities to look elsewhere for new generating capacity. Geothermal energy is a viable alternative since it is environmentally safe, reasonably abundant, and generally cost-competitive. Many utilities have invested large sums of money in exploration projects. This action on the part of utilities is extremely unusual for any fuel form, let alone one in the relatively early stages of development. Private and public utilities have entered into joint ventures with various development companies to locate producible reservoirs. For example, SDG&E has joined Chevron and Magma in developing resources in the Imperial Valley. Utilities need all the available generating options they can get and will continue to give attention to geothermal energy.

We have thus far discussed the geothermal industry in terms of the players and their particular reasons for entrance into this field. Now that the structure of the industry has been identified, it is important to delineate each player's level of participation. Well drilling and land acquisition will be the two parameters that will be utilized to quantify participation in geothermal development. Within these parameters development activity will be analyzed prior to and after the establishment of the Department of Energy (in 1975 the Energy Research and Development Agency became DOE).

3.2 Land Acquisition

Prior to 1975 the integrated oil companies were the major leaseholder on Federal lands** with 31.2% of all land leased. This trend has continued with 35% of all land leased since then under their control.

* MCR is a subsidiary of McCulloch Oil resources and has for this analysis been classified as a geothermal independent as of 1980.

** For the purpose of this analysis leases issued on Federal land are not segmented into competitive or non-competitive issuances.

The Oil Producers, prior to 1975, controlled 28.4% of the land leased; however since then they have accounted for only 5% of land acquisition, which may be due to lack of sufficient incentive in the geothermal area and a move to different investment opportunities.

The Large Industrial Firms held approximately 23% of the leased acreage prior to 1975, but this percentage has dropped by almost 40% since 1975 on new acreage leased. This may be the result of further diversification by these firms.

The Independent Geothermal Firms have maintained a relatively constant percentage in their lease acquisition, which reemphasizes their trend of leasing land, selling to larger firms and starting the leasing process all over again.

The most significant change in leasing has occurred in the sector of private individuals involved in geothermal development. Prior to 1975, private holdings were less than 1%; since then they have accounted for 34% of the land leased. However, this figure is somewhat misleading, as the leases are mainly non-competitive and are in areas of relatively low development. Yet, this tremendous increase in leasing by private individuals points out the speculative nature of leasing activity.

Tables 7 and 8 present the percentages of Federal land leased by the various geothermal participants prior to and after 1975.

3.3 Well Drilling

Well drilling activity has been dominated by the integrated oil companies. Prior to 1975, 58% of all wells drilled were by them. A significant factor contributing to this large percentage was the tremendous drilling activity of Union Oil at the Geysers. If the well drilling activity at the Geysers were removed from our analysis, then integrated oil firms would have accounted for only 20% of all wells drilled. These firms not only dominated early drilling statistics but have actually increased their level of activity after 1975. Of all wells drilled since 1975, the integrated oil companies have accounted for 65% of the total. Our second group, the oil producers, has increased its level of involvement substantially. Through 1975, the oil producers were responsible for only 1/2% of the wells drilled. After 1975, their activity has increased by a factor of 6, to 3% of the overall total. The large industrial firms' percentage of wells drilled has remained approximately 9% of the total wells drilled. The independent geothermal firms have maintained their position as the number two group in wells drilled; however, in terms of their relative activity, they have slipped from 29% to 15.5% of the wells drilled since 1975. While their percentage of the total has decreased, they are still an extremely active and significant force in geothermal development. This decrease in well drilling activity is consistent with their previously mentioned philosophy of leasing the land and leaving the drilling to the integrated oil companies. Our final group, which is government/institutions, accounts for only minor activity and this is not expected to change. Tables 9 and 10 summarize well drilling activity, showing percent of wells drilled thorough 1975 both

TABLE 7

**PERCENTAGE OF LAND LEASED (FEDERAL) THROUGH
1975 BY GEOTHERMAL INDUSTRY**

Developer Category	% of Land Leased
Integrated Oil Companies	31.2
Oil Producers	28.4
Large Industrial Firms	23.2
Independent Geothermal Firms	16.3
Private	0.9

TABLE 8

**PERCENTAGE OF LAND LEASED (FEDERAL) AFTER
1975 BY GEOTHERMAL INDUSTRY**

Developer Category	% of Land Leased
Integrated Oil Companies	35.0
Oil Producers	5.0
Large Industrial Firms	13.0
Independent Geothermal Firms	13.0
Private	34.0

TABLE 9

PERCENTAGE OF WELLS DRILLED THROUGH 1975
BY GEOTHERMAL INDUSTRY CATEGORY

Developer Category	% of Wells Drilled
Integrated Oil Companies	58.1
Oil Producers	0.5
Large Industrial Firms	8.3
Independent Geothermal Firms	29.2
Government/Institutions	3.9

TABLE 10

PERCENTAGE OF WELLS DRILLED THROUGH 1975 BY GEOTHERMAL
INDUSTRY CATEGORY (EXCLUDING THE GEYSERS)

Developer Category	% of Wells Drilled
Integrated Oil Companies	19.8
Oil Producers	4.5
Large Industrial Firms	28.1
Independent Geothermal Firms	36.8
Government/Institutions	10.8

which is government/institutions, accounts for only minor activity and this is not expected to change. Tables 9 and 10 summarize well drilling activity, showing percent of wells drilled thorough 1975 both with and without the Geysers. Tables 11 and 12 present the same summary for the post 1975 time period. Tables 13 and 14 present wells drilled by organizational category. Tables 15 through 19 depict the history of geothermal well drilling by organizational category highlighting individual firms and drilling activity on a yearly basis.

TABLE 11

**PERCENTAGE OF WELLS DRILLED AFTER 1975
BY GEOTHERMAL INDUSTRY CATEGORY**

Developer Category	% of Wells Drilled
Integrated Oil Companies	65.1
Oil Producers	3.4
Large Industrial Firms	9.1
Independent Geothermal Firms	15.6
Government/Institutions	6.8

TABLE 12

**PERCENTAGE OF WELLS DRILLED AFTER 1975 BY GEOTHERMAL
INDUSTRY CATEGORY (EXCLUDING THE GEYSERS)**

Developer Category	% of Wells Drilled
Integrated Oil Companies	40.6
Oil Producers	5.8
Large Industrial Firms	15.4
Independent Geothermal Firms	26.6
Government/Institutions	11.6

TABLE 13

**WELLS DRILLED BY GEOTHERMAL INDUSTRY
1960-1975 AND 1976-1981**

Category of Organization	1960-1975	1976-1981	TOTALS (1960-1981)
Integrated Oil Firms	237	229	466
Oil Producing Firms	2	12	14
Large Industrial Firms	34	32	66
Independent Geothermal Firms	119	55	174
Government/Institutions	<u>16</u>	<u>24</u>	<u>40</u>
TOTALS	408	352	760

TABLE 14

**WELLS DRILLED BY GEOTHERMAL INDUSTRY
1960 TO 1981**

Category of Organization	Drilling Year				TOTAL (1960-1981)
	1960-66	1967-71	1972-76	1977-81	
Integrated Oil Firms	26	60	200	180	466
Oil Producing Firms	0	1	3	10	14
Large Industrial Firms	6	8	21	31	66
Independent Geothermal Firms	41	23	63	47	174
Government/Institutions	<u>0</u>	<u>4</u>	<u>15</u>	<u>21</u>	<u>40</u>
TOTALS	73	96	302	289	760

TABLE 15

WELLS DRILLED PER YEAR BY INTEGRATED OIL COMPANIES

YEAR	COMPANY NAME									
	CHEVRON	EARTH ENERGY	GETTY OIL	GULF OIL	OCCIDENTAL	PHILLIPS	SHELL	SUNEDCO	UNION OIL	TOTAL
1960										0
1961									2	2
1962										0
1963									7	7
1964		2							9	11
1965		1							2	3
1966									3	3
1967									2	2
1968									9	9
1969									6	6
1970	6								18	24
1971	1								18	19
1972	1								13	14
1973				2					18	20
1974	5					1	1	2	25	34
1975	20			5		19	4		35	83
1976	2			4		6	3		34	49
1977	1			4		10	5		19	39
1978	12		2			8	2	1	19	44
1979	10					4	4	2	25	45
1980	5				2	1	5	3	31	47
1981*								1	4	5
TOTAL	63	3	2	15	2	49	24	9	299	466

*Partial Year Estimates

TABLE 16
WELLS DRILLED PER YEAR BY OIL PRODUCING COMPANIES

YEAR	COMPANY NAME					
	HUNT OIL	MAPCO	McCULLOCH	SAN JUAN OIL	THERMAL POWER	TOTAL
1960						0
1961						0
1962						0
1963						0
1964						0
1965						0
1966						0
1967						0
1968						0
1969						0
1970			1			1
1971						0
1972						0
1973						0
1974						0
1975				1		1
1976					2	2
1977			1			1
1978	1		1		1	3
1979		1	2		2	5
1980		1				1
1981*						0
TOTAL	1	2	5	1	5	14

*Partial Year Estimates

TABLE 17

WELLS DRILLED PER YEAR BY LARGE INDUSTRIAL FIRMS

YEAR	COMPANY NAME							TOTAL
	AMAX EXPLORATIONS	AMINOIL	ANADARKO	BARWELL	BURMAH OIL AND GAS	GEDCO	VULCAN THERMAL	
1960								0
1961							6	6
1962								0
1963								0
1964								0
1965								0
1966								0
1967		1			2			3
1968								0
1969					3			3
1970					1			1
1971					1			1
1972					2			2
1973					3			3
1974					4			4
1975		3			8			11
1976		1						1
1977		6						6
1978		3						3
1979		5	3					8
1980	1	6				2		9
1981*	4			1				5
TOTAL	5	25	3	1	24	2	6	66

*Partial Year Estimates

TABLE 18

WELLS DRILLED PER YEAR BY INDEPENDENT GEOTHERMAL FIRMS

YEAR	COMPANY NAME													
	AMERICAN THERMAL	CALIFORNIA ENERGY	GEOTHERMAL ENERGY & MINERAL	GEOTHERMAL KINETICS	GEOTHERMAL RESOURCES	HAWAII THERMAL	IMPERIAL THERMAL	MAGMA	MCR	NEVADA THERMAL POWER	PACIFIC ENERGY	REPUBLIC GEOTHERMAL	SIERRA PACIFIC	THERMOGENICS
1960								14		2				16
1961			1			3	1	5		2				12
1962								1		2				3
1963							2							2
1964			1										4	5
1965							1					2		3
1966														0
1967											2			2
1968											4			4
1969											1		1	2
1970					1			1				6		8
1971											1	6		7
1972								3			4			7
1973				1				4			2	1		8
1974	1					2		5			1	10		19
1975								3		1	2	15		21
1976											1	7		8
1977		3					1	1				1		6
1978								5				2		10
1979				2			1					15		20
1980									1			5		10
1981*													1	1
TOTAL	1	3	2	3	1	5	6	42	1	7	18	70	4	174

*Partial Year Estimates

TABLE 19

WELLS DRILLED PER YEAR BY GOVERNMENT AND INSTITUTIONS

YEAR	COMPANY NAME						TOTAL
	DOE	EL CENTRO (CITY)	LASL	USGS	UNIVERSITY OF HAWAII	UNIVERSITY OF UTAH	
1960							
1961							0
1962							0
1963							0
1964							0
1965							0
1966							0
1967							0
1968							0
1969							0
1970							0
1971		2		2			4
1972			1				1
1973							0
1974			1			5	6
1975	2		2		1		5
1976	3						3
1977	4						4
1978	9			8			17
1979							0
1980							0
1981*							0
TOTAL	18	2	4	10	1	5	40

*Partial Year Estimates

4.0 DEVELOPMENT STATUS

At present, nearly all electric power-on-line from hydrothermal resources is from The Geysers field in Northern California. Current generating capacity at this site is 902 MWe. The only operational geothermal electric power plants in the continental United States outside The Geysers are the Union Oil/Southern California Edison 10 MWe plant at Brawley and the Magma Power 10 MWe binary plant at East Mesa. Both these sites are located in California's geothermally rich Imperial Valley. Recently a 3 MWe plant at Puna, Hawaii became operational. Table 20 presents a listing of all geothermal electric power plants that are operational.

The first geothermal electric power plant in the United States became operational in 1960 at the Geysers with a net output of 11 MWe. The rest of the decade saw three more plants brought on-line providing an additional 67 MWe. A substantial increase in development activity occurred during the 1970's and nine additional power plants were brought on-line with a total net output of 585 MWe. In 1980, four additional power plants became operational. Two of these plants were at the Geysers providing an additional 239 MWe output; the others were the aforementioned plants at Brawley and East Mesa. Figure 3 presents the development of geothermal electric power plants.

Geothermal power plants in the United States utilize steam, flash, and binary power cycles. Steam power cycles are the most prevalent as a result of the utilization of the vapor dominated resource at the Geysers. Hybrid power plants are in the development stage with the first plant which is to be a 20 MWe unit at the Mono-Long Valley site scheduled to become operational in 1985. Figure 4 illustrates the actual and proposed power plant development by plant type.

The construction of power plants and well drilling activity have an interdependent relationship. Well drilling successes have led to the design and construction of power plants. Power plants need production wells to support them as well as injection wells where required. The successful operation of these plants stimulates further drilling activity by confirming the viability and reliability of geothermal technology. This interrelationship is, to a large extent, a type of closed loop feedback system.

This effect is clearly illustrated by the development activity which occurred during the 1970's. Nine plants with a capacity of 585 MWe were brought on-line during this time. Concurrently with the power plant construction, well drilling activity was taking place at a frenzied pace with over 200 production wells spudded. A large number of these wells were drilled to support power generation, and it was during this time that the drilling of "wildcat" production wells (a technique employed in the oil and gas industry) became common. Table 21 presents the number and type of wells drilled from 1960 to 1981. Figure 5 presents the total number of wells drilled during this period on a cumulative basis. Figures 6 through 13 present a comparison of drilling activity for each type of well during the last 20 years.

A detailed presentation of current development status at each of the 56 high temperature sites is presented in Appendix A. Current leasing information, well drilling (including number spudded, type, developer and year drilled), and power plant status is presented.

TABLE 20

EXISTING U.S. HYDROTHERMAL ELECTRIC POWER FACILITIES

AREA	PLANT	START YEAR	OPERATOR ⁺	UTILITY	PLANT TYPE	NET OUTPUT MWe
<u>CALIFORNIA</u>						
GEYSERS	GEYSERS #1	1960	UMT	PG&E	S	11
GEYSERS	GEYSERS #2	1963	UMT	PG&E	S	13
GEYSERS	GEYSERS #3	1967	UMT	PG&E	S	27
GEYSERS	GEYSERS #4	1968	UMT	PG&E	S	27
GEYSERS	GEYSERS #5	1971	UMT	PG&E	S	53
GEYSERS	GEYSERS #6	1971	UMT	PG&E	S	53
GEYSERS	GEYSERS #7	1972	UMT	PG&E	S	53
GEYSERS	GEYSERS #8	1972	UMT	PG&E	S	53
GEYSERS	GEYSERS #9	1973	UMT	PG&E	S	53
GEYSERS	GEYSERS #10	1973	UMT	PG&E	S	53
GEYSERS	GEYSERS #11	1975	UMT	PG&E	S	106
GEYSERS	GEYSERS #12	1976	UMT	PG&E	S	106
GEYSERS	GEYSERS #15	1979	TGI/PEC	PG&E	S	55
GEYSERS	GEYSERS #13	1980	AMINOIL	PG&E	S	129
GEYSERS	GEYSERS #14	1980	UMT	PG&E	S	110
IMPERIAL VALLEY	EAST MESA #1	1980	MAGMA	SDG&E	B	10
BRAWLEY	SCE PILOT	1980	UNION OIL	SCE	F	10
<u>HAWAII</u>						
PUNA	HGP-A	1981	STATE OF HAWAII	HELCO	F	3
TOTAL MWe on-Line						925

⁺UMT - Union Magma Thermal

TGI/PEC - Thermogenics Inc./Pacific Energy Corp.

PG&E - Pacific Gas and Electric Company

Plant Type:

S = Steam

B = Binary

F = Flash

Source: Geothermal Progress Monitor

FIGURE 3
ON-LINE AND PROPOSED GENERATING CAPACITY
(BASED ON PLANS OF DEVELOPERS/UTILITIES)

FIGURE 4

ON-LINE AND PROPOSED GENERATING CAPACITY
BY POWER CYCLE TYPE
(BASED ON ANNOUNCED PLANS OF
UTILITIES AND DEVELOPERS)

TABLE 21

NUMBER AND TYPE OF WELLS DRILLED FROM 1960 THROUGH 1981

TYPE OF WELL	YEAR DRILLED				TOTAL
	1960-66	1967-71	1972-76	1977-81	
Production	21	55	134	134	344
Injection	1	1	5	25	32
Exploratory	2	0	26	28	56
Temperature Gradient	1	7	30	19	57
Observation	31	0	14	31	76
Unknown	10	4	2	26	92
Abandoned(1)	5	28	24	6	63
Suspended(1)	2	1	17	20	40
TOTAL	73	96	302	289	760

(1) Well records indicate that a well, type unknown, was drilled and subsequently suspended or abandoned in that year.

FIGURE 5

WELLS DRILLED BETWEEN 1960 AND 1981

Figure 6

PRODUCTION WELLS DRILLED FROM
1960 THROUGH 1981

Figure 7
OBSERVATION WELLS DRILLED FROM
1960 THROUGH 1981

Figure 8
WELLS DRILLED (TYPE UNKNOWN) AND
ABANDONED FROM 1960 THROUGH 1981

Figure 9
TEMPERATURE GRADIENT WELLS DRILLED FROM
1960 THROUGH 1981

Figure 10

EXPLORATORY WELLS DRILLED FROM
1967 THROUGH 1981

Figure 11
WELLS DRILLED (TYPE UNKNOWN) AND
SUSPENDED FROM 1960 THROUGH 1981

Figure 12
INJECTION WELLS DRILLED FROM
1960 THROUGH 1981

Figure 13
WELLS DRILLED (TYPE UNKNOWN) FROM
1960 THROUGH 1981

Developers and utilities have proposed that an additional 43 plants will become operational by 1990. If these projects are successful an additional 2234 MWe will be on-line resulting in a total power-on-line capacity of 3159 MWe by 1990. Most of these plants will be located in California (34 units), Nevada (3 units), Utah (3 units), Hawaii (1 unit), Idaho (1 unit), and New Mexico (1 unit). Table 22 details the proposed plant location, type of plant, net output (MWe), year on-line, and the developer/utility.

TABLE 22

PROPOSED GEOTHERMAL ELECTRIC PLANTS

STATE	AREA	DEVELOPER	UTILITY	PLANT	PLANT TYPE	NET OUTPUT MWe	YEAR ON LINE
CA	Brawley	Union Oil	SCE				
CA	Brawley	CU-I Venture	CDWB		Flash	45	1984
CA	Brawley	Union Oil	SCE	SCE			
CA	Coso	California Energy	US Navy	Coso #1	Flash	20	1983
CA	Coso	California Energy	US Navy	Coso #2	Flash	55	1989
CA	East Mesa	Republic Geothermal	SDG&E		Flash	50	1982
CA	Geysers		CDWR	Binkley	Steam	55	1986
CA	Geysers	MCR Geothermal	CDWR	Bottle Rock	Steam	55	1984
CA	Geysers	NCPA	NCPA	NCPA #1	Steam	66	1985
CA	Geysers	Shell Oil	NCPA	NCPA #2	Steam	110	1982
CA	Geysers	Occidental Geo. Inc.		OXY #1		80	1988
CA	Geysers	Aminoil USA	SMUD	SMUD #1	Steam	75	1984
CA	Geysers		SMUD	SMUD #2	Steam	55	
CA	Geysers		SMUD	SMUD #3	Steam	55	
CA	Geysers	Geothermal Kinetics	CDWR	So. Geysers	Steam	55	1986
CA	Geysers	Aminoil USA	PG&E	Unit #16	Steam	110	1983
CA	Geysers	Union-Magma-Thermal	PG&E	Unit #17	Steam	110	1982
CA	Geysers	Union-Magma-Thermal	PG&E	Unit #18	Steam	110	1982
CA	Geysers	Aminoil USA	PG&E	Unit #19	Steam	55	1986
CA	Geysers	Union-Magma-Thermal	PG&E	Unit #20	Steam	110	1984
CA	Geysers	Union-Magma-Thermal	PG&E	Unit #21	Steam	110	1986
CA	Geysers		PG&E	Unit #22	Steam	110	1990
CA	Geysers		PG&E	Unit #23	Steam	110	1990
CA	Geysers		PG&E	Unit #24	Steam	110	1990
CA	Heber	Chevron	SDG&E		Binary	45	1985
CA	Heber	Chevron	SCE	SCE #1	Flash	50	1983
CA	Heber	Chevron	SCE	SCE #2	Flash	100	1986
CA	Mono-Long Valley	Magma Power	SCE		Hybrid	20	1985
CA	Niland	Union Oil	SCE	SCE			
CA	Niland	Union Oil	SCE	SCE Pilot		10	1982
CA	Niland	Magma Power	SDG&E	SDG&E #1	Flash	26	1983
CA	Niland	Magma Power	SDG&E	SDG&E #2	Flash	49	1985
CA	Wendel-Amedee	Geoproduts	CDWR		Hybrid	50	1985
CA	Westmorland	Republic Geothermal			Flash	48	1984
HI	Puna	Thermal-Dillingham	HELCO			25	1988
ID	Raft River	INEL/EG&G			Binary	5	
NM	Valles Caldera	Union Oil	PNM	Baca #1	Flash	45	1983
NV	Northern Nevada	Phillips Petroleum	NORNEV	NORNEV #1	Binary	10	1982
NV	Northern Nevada	Phillips Petroleum	NORNEV	NORNEV #2	Binary	10	
NV	Northern Nevada	Phillips Petroleum	NORNEV	NORNEV #3	Flash	10	
UT	Roosevelt H.S.	Phillips Petroleum	UP&L	UP&L #1	Flash	20	1983
UT	Roosevelt H.S.	Phillips Petroleum	UP&L	UP&L #2	Flash		
UT	Roosevelt H.S.	Phillips Petroleum	UP&L	UP&L #3			
TOTAL						2,234	

Source: Geothermal Progress Monitor #5

5.0 MARKET PENETRATION

The United States Geological Survey (USGS) estimates that high temperature ($>150^{\circ}\text{C}$) hydrothermal resources in the United States have the potential for producing about 140,000 megawatts of electric power for 30 years. During the first quarter of 1980 the Division of Geothermal Energy (DGE) within the Department of Energy (DOE) established a Task Force to evaluate the extent to which these resources might be realistically used over the next 20 years, and to assess the probable impact of Federal programs on that utilization. The Task Force was comprised of a team of senior government officials and four non-government organizations. A Review Panel was established and served to present industry perspective for this analysis. There were six major segments of the analysis:

- Development of a Resource Data Base
- Development of Plant and Field Cost Data Base
- Development of Regional Economic Data Base
- Development of the Market Shares Estimation Model
- Assessment of the Federal/DOE Programs and Sensitivity Analysis
- Documentation.

Previous forecasts of hydrothermal electric power development have ranged from aggregates based on the resource base to those based on comparison of the busbar costs of hydrothermal electricity and the busbar costs of electricity generated through alternatives. As the busbar costs for electricity generated by fossil and nuclear fueled power plants increased during the last few years it became apparent that a favorable busbar cost alone will not induce developers and utilities to invest in hydrothermal electric power systems. Interviews conducted with geothermal developers, utilities, and financial institutions have confirmed that, in addition to a favorable busbar cost of electricity, factors such as rate-of-return on investment, project size, and capital-at-risk will be major determinants in investment decisions. The Market Shares Task Force was attempting for the first time to assess the potential market share of hydrothermal electric systems on the basis of a simulation of the investment decision behaviour of the private sector.

The Market Penetration model generated estimates of power-on-line during the period 1980-2000 by projecting development schedules of installed hydrothermal electric system capacities at identified and unidentified sites. Table 23 presents these results. The first phase of the market penetration effort was completed in the spring of 1981.

The second phase of the market shares estimation effort is currently in progress. The emphasis has shifted from the task of market penetration analysis to the evaluation of the total benefits of the program, and it should be viewed in terms of its contribution -- or the net benefit -- to society.

TABLE 23

NATIONAL HYDROTHERMAL ELECTRIC POWER ESTIMATES

YEARS	PROJECTED NUMER OF MEGAWATTS WITH A LIKELIHOOD		
	≥ 5%	≥ 50%	≥ 90%
1985	2,161*	1,699	1,754
1990	4,024	4,024	3,554
1995	6,924	6,414	6,244
2000	9,834	9,144	7,684

*** Represents Proposed Plans for Utilities as Published in GPM #5.**

The program will be assessed by the impacts on increasing hydrothermal market share, reducing the cost of delivered energy, savings to consumers, increasing the probability of successful discoveries, and decreasing the risk of reservoir and plant failure. Analyses are currently underway to assess its impact both in the areas of market penetration and societal benefit. Results of this effort will be completed by December of this year and new estimates will be generated indicating the market share hydrothermal energy is likely to capture.

APPENDIX A
SITE SPECIFIC INFORMATION

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Known Geothermal Resource Areas With High Levels of Developmental Activity

CALIFORNIA

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SITE: Brawley, Imperial County, California

The Brawley site is located in the Imperial Valley where numerous other liquid-dominated resources are under development. Most of the surrounding land is utilized for various agricultural purposes. The resource site is located approximately 10 miles from the town of Brawley (pop. 15,000).

Initial development activities were undertaken by Union Oil in 1974 and 1975. Union Oil's agreement with Southern California Edison led to the construction and operation of a 10 MWe binary plant, which came on-line in June 1980. It also has the distinction of being the first flashed-steam plant in the United States. If plant operation is successful, an additional 50 MWe may be on line by 1985.

Additionally, McCullough Geothermal Resources and the California Department of Water are developing this resource under a DOE loan guarantee. The proposed plant is a 45 MWe facility scheduled to be on-line by 1984. McCullough and Geothermal Kinetics are currently engaged in resource assessment activities.

SITE: Brawley, Imperial County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,500
Reservoir Area (sq. miles): 9.9
Temperature (°C): 253 (487°F)
Total Dissolved Solids (ppm): 100,000
Electric Energy Potential (MWe 30 years): 640

2. LEASING: NONE IDENTIFIED

3. WELL DRILLING:

Total Wells Spudded: 38

Production: 17	Observation: 1
Injection: 2	Abandoned: 9
Exploratory: 0	Suspended: 1
Temperature Gradient: 2	Unknown: 6

Average Well Depth (ft): 4,560
Maximum Well Depth (ft): 13,381
Average Temperature (°F): 475
Maximum Temperature (°F): 525
Average Flow Rate (lbs/hr): 415,000

Well Drillings by Year

	COMPANY							TOTAL
	REPUBLIC GEOTHERMAL	UNION	CHEVRON	McCULLOUGH	OCCIDENTAL	MCR	PHILLIPS	
1974	1	5						6
1975		7						7
1976		2						2
1977		3	1					4
1978		5	6	1				12
1979				1			1	2
1980		2			1	1	1	5
TOTAL	1	24	7	2	1	1	2	38

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (8)	4-23-80
APD's (4)	5-14-80
APD's (10)	Pending

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
SCE PILOT	1980	10	O	Flash	SCE/Union Oil
	?	?	P	?	SCE/Union Oil
	1984	45	P	Flash	CDWE/CU-I Venture
SCE	?	?	P	?	SCE/Union Oil

SITE: Coso Hot Springs, Inyo County, California

Coso Hot Springs is located in the Mojave Desert east of the Sierra Nevada Mountain Range. The closest population center is the town of China Lake (pop. 14,000), approximately 35 miles away. About 90% of the high grade resource lies within the China Lake Naval Weapon Center.

By 1977, 18 temperature gradient wells had been drilled in the area. The Navy, in cooperation with California Energy, is currently developing this site. An Environmental Impact Statement was issued in March 1981 for Coso #1 and a 20 MWe plant is scheduled to go on-line in 1983. Assuming the successful operation of the first plant, a 55 MWe plant will be scheduled for 1989.

SITE: Coso Hot Springs, Inyo County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,875
Reservoir Area (sq. miles): 10.5
Temperature (°C): 220 (428°F)
Total Dissolved Solids (ppm): 6,000
Electric Energy Potential (MWe 30 years): 650

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	79,172	0	8,430	87,602
Acreage Leased	?	0	0	?

Major Lease Holders - Department of the Navy

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	0	0	0	0

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	58	10	30	18

3. WELL DRILLING:

Total Wells Spudded: 3

Production: 2	Observation: 0
Injection: 0	Abandoned: 0
Exploratory: 1	Suspended: 0
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 2,188
Maximum Well Depth (ft): 4,848
Average Temperature (°F): 321
Maximum Temperature (°F): 387
Average Flow Rate (lbs/hr): ?

Well Drillings by Year

	COMPANY	
	CER	TOTAL
1977	3	3
TOTAL	3	3

4. PERMITTING INFORMATION:

Type

Date Approved/Completed

EAR

9-80

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
Coso #1	1983	20	P	Flash	CA Energy/U.S. Navy
Coso #2	1989	55	P	Flash	CA Energy/U.S. Navy

SITE: East Mesa, Imperial County, California

The East Mesa site is located in the Imperial Valley geothermal resource area. The terrain is mostly flat irrigated land and desert shrubs. A natural water shortage exists in the surrounding area. The towns of Holtville and El Centro (combined pop. 24,000) are within 15 miles of the site.

Development of the site was begun in the early 1970's by Magma Power company, which drilled numerous wells. In the mid 1970's Republic Geothermal became an active participant by drilling exploratory wells in the area.

In 1980 a 10 MWe binary plant developed by Magma came on-line. Start up of the plant was initially delayed due to problems with hydrocarbon seals. The plant's heat rejection system utilizes an evaporative pond instead of cooling towers. The plant was temporarily shut down in late 1980 due to the loss of several turbine blades. The plant was back on-line in early Spring 1981, but it has yet to achieve full operational status. A 20 MWe flash plant is scheduled to be on-line by 1983. Republic Geothermal will be the developer for this proposed facility.

SITE: East Mesa, Imperial County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 5,906
Reservoir Area (sq. miles): 12.4
Temperature (°C): 182 (360°F)
Total Dissolved Solids (ppm): 2,500
Electric Energy Potential (MWe 30 years): 360

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	58,721	4,840	0	63,561
Acreage Leased	18,729	0	0	18,729

Major Lease Holders - Republic, Magma, Union

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	14	9	0	9

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	28	0	12	16

3. WELL DRILLING:

Total Wells Spudded: 33

Production: 9	Observation: 1
Injection: 6	Abandoned: 2
Exploratory: 7	Suspended: 0
Temperature Gradient: 7	Unknown: 1

Average Well Depth (ft): 6,369
Maximum Well Depth (ft): 7,659
Average Temperature (°F): 426
Maximum Temperature (°F): 498
Average Flow Rate (lbs/hr): 172,800

Well Drillings by Year

	COMPANY		
	MAGMA	REPUBLIC GEOTHERMAL	TOTAL
1972	1		1
1973	1		1
1974	3	9	12
1975		6	6
1977	1	1	2
1978	5	1	6
1979		14	14
1980		1	1
TOTAL	11	32	43

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (1)	8-19-75
APD's (4)	9-12-75
APD's (4)	12-30-75
APD's (1)	2-10-76
APD's (1)	11-30-76
APD's (2)	7-29-77
APD's (3)	2-28-78
EAR	3-80

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
	1980	10	0	Binary	SDG&E/Magma Power Republic
	1982	50	P	Flash	SDG&E/Magma Geothermal

SITE: The Geysers, Sonoma and Lake Counties, California

The Geysers in California has become synonymous with geothermal energy productions. Production wells were drilled at the Geysers field as early as the 1920's, allowing small amounts of electric power to be generated. Present development of this field can be traced to the mid 1950's when Magma Power Company initiated drilling operations in the area. Electric power production began in 1960 with the start up of a 12 MWe facility. During the next twenty years, intense development of the area was undertaken resulting in the Geysers being the largest geothermal facility in the world.

Current power-on-line at the Geysers stands at 902 MWe with approximately an additional 1500 MWe to be added by 1990. The Geysers is a unique area since the resource is steam- rather than liquid-dominated. It is expected, however, that liquid-dominated resources will be found along the periphery of this field.

Development Status of Selected Units of The Geysers

For PG & E unit #16 (110 MWe by 1983), an application for certification was resubmitted, including additional analyses of air quality for hydrogen sulfide. For PG & E unit #17 (110 MWe, 1982), the application for certification was approved and construction was initiated during June of 1981. PG & E unit #18 (110 MWe, 1986) may experience a delay in operational status due to questions concerning proof of resource. At PG & E unit #20 (110 MWe, 1984), the resource has yet to be confirmed and may require a site relocation, PG & E units 21 through 24 are in the long range planning stage. The amount of power and year on-line are contingent on an adequate steam supply. For SMUD #1 (75 MWe, 1984), the application for certification was received on March 25, 1981 and construction is underway. SMUD #2 and #3 may be pushed back to long term development.

SITE: The Geysers, Sonoma and Lake Counties, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 38.6
Temperature (°C): 237 (459°F)
Total Dissolved Solids (ppm):
Electric Energy Potential (MWe 30 years): 1610

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	15,155	0	376,030	391,185
Acreage Leased	15,155	0	-	15,155

Major Lease Holders - Aminoil, Union-Magma-Thermal, Shell,
Occidental

3. WELL DRILLING:

Total Wells Spudded: 378

Production: 265	Observation: 2
Injection: 2	Abandoned: 43
Exploratory: 12	Suspended: 10
Temperature Gradient: 3	Unknown: 41

Average Well Depth (ft): 6,443
Maximum Well Depth (ft): 11,440
Average Temperature (°F): 380
Maximum Temperature(°F): ?
Average Flow Rate (lbs/hr): 90,000

Well Drillings by Year

	COMPANY													
	CHEVRON	SUNOCO	OCCIDENTAL	GEO THERMAL KINETICS	UNION	SHELL	PACIFIC ENERGY	BURMAR	AMINOIL	THERMOGENICS	THERMAL POWER	MCCULLOCH GEO THERMAL	PHILLIPS	TOTAL
1961					2									2
1963					6									6
1964					7									7
1965					2									2
1966					3									3
1967					2		2	2	1					7
1968					9		4							13
1969					6		1	3		1				11
1970					15			1						16
1971					9		1	1						11
1972					12		4	2						18
1973				1	16		2	3						22
1974		2			17	1	1	4						25
1975					14	4	2	8	3		1			32
1976	1				13	3	1		1			1		20
1977					14	5			6				1	26
1978					11	2			3	3				19
1979				2	15	4			5	2				28
1980			1		25	5			6	4				41
1981					3					1				4
TOTAL	1	2	1	3	201	24	18	24	25	11	1	1	1	313

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (2)	9-6-74
APD's (1)	4-9-75
APD's (1)	9-12-75
APD's (1)	10-19-75
APD's (1)	1-30-76
APD's (2)	8-4-76
APD's (2)	10-4-76
APD's (2)	3-18-76
APD's (4)	5-16-77
APD's (1)	4-20-78
APD's (2)	8-17-78
APD's (2)	6-7-79

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (1)	10-31-79
APD's (2)	5-5-80
AFC (PGE #14)	12-80
AFC (PGE #16)	Pending
AFC (PGE #20)	Pending
NOI (NCPA 1)	3-80
AFC (NCPA 2)	3-12-80
NOI (DWR)	11-19-79
AFC (SMUD 1)	Pending

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
Unit #1	1960	11	0	Steam	PG&E/Union-Magma-Thermal
Unit #2	1963	13	0	Steam	PG&E/Union-Magma-Thermal
Unit #3	1967	27	0	Steam	PG&E/Union-Magma-Thermal
Unit #4	1968	27	0	Steam	PG&E/Union-Magma-Thermal
Unit #5	1971	53	0	Steam	PG&E/Union-Magma-Thermal
Unit #6	1971	53	0	Steam	PG&E/Union-Magma-Thermal
Unit #7	1972	53	0	Steam	PG&E/Union-Magma-Thermal
Unit #8	1972	53	0	Steam	PG&E/Union-Magma-Thermal
Unit #9	1973	53	0	Steam	PG&E/Union-Magma-Thermal
Unit #10	1973	53	0	Steam	PG&E/Union-Magma-Thermal
Unit #11	1975	106	0	Steam	PG&E/Union-Magma-Thermal
Unit #12	1979	106	0	Steam	PG&E/Union-Magma-Thermal
Unit #13	1980	129	0	Steam	PG&E/Aminoil USA
Unit #14	1980	110	0	Steam	PG&E/Union-Magma-Thermal
Unit #15	1979	55	0	Steam	PG&E/Thermogenics
Binkley	1986	55	P	Steam	CDWR/
Bottle Rock	1984	55	P	Steam	CDWR/MCR Geothermal
NCPA #1	1985	66	P	Steam	NCPA/NCPA
NCPA #2	1982	110	P	Steam	NCPA/Shell Oil
OXY #1	1988	80	P	?	Occidental Geo. Inc.

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
SMUD #1	1984	75	P	Steam	SMUD/Aminoil USA
SMUD #2	?	55	P	Steam	SMUD/
SMUD #3	?	55	P	Steam	SMUD/
So. Geysers	1986	55	P	Steam	CDWR/Geo. Kinetics
Unit #16	1983	110	P	Steam	PG&E/Aminoil USA
Unit #17	1982	110	P	Steam	PG&E/Union-Magma-Thermal
Unit #18	1982	110	P	Steam	PG&E/Union-Magma-Thermal
Unit #19	1986	55	P	Steam	PG&E/Aminoil USA
Unit #20	1984	110	P	Steam	PG&E/Union-Magma-Thermal
Unit #21	1986	110	P	Steam	PG&E/Union-Magma-Thermal
Unit #22	1990	110	P	Steam	PG&E/
Unit #23	1990	110	P	Steam	PG&E/
Unit #24	1990	110	P	Steam	PG&E/

SITE: Heber, Imperial County, California

The Heber site is one of six geothermal resources located in the Imperial Valley. Heber is in one of the most seismically active regions of North America. The extremely flat topography of the area is sensitive to any disturbance of runoff patterns. The population of the area is sparse and the town of Heber, which is located approximately 10 miles from the site, has less than 1,000 inhabitants.

Initially, development of the area was undertaken in the early 1970's primarily by Magma Power & Chevron. Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E) are both active in the development of this resource. The SDG&E plant will be a binary system capable of producing 45 MWe. Power-on-line for this plant is scheduled for 1985, and the engineering design phase is currently in progress.

SITE: Heber, Imperial County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 16.1
Temperature (°C): 175 (347°F)
Total Dissolved Solids (ppm): 20,000
Electric Energy Potential (MWe 30 years): 500

2. LEASING: NONE IDENTIFIED

3. WELL DRILLING:

Total Wells Spudded: 38

Production: 14
Injection: 0
Exploratory: 6
Temperature Gradient: 0
Observation: 2
Abandoned: 16
Suspended: 0
Unknown: 0

Average Well Depth (ft): 5,671
Maximum Well Depth (ft): 11,014
Average Temperature (°F): 182
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drillings by Year

	COMPANY					TOTAL
	CHEVRON	EL CENTRO	REPUBLIC	UNION	MAGMA	
1971	1	2	6	8		17
1972	1				2	3
1973					3	3
1974	3					3
1975	3		1			4
1976	1			4		5
TOTAL	9	2	7	12	5	35

4. PERMITTING INFORMATION:

Type

Date Approved/Completed

AFC

1-80

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
?	1985	45	P	Binary	SDGE/
SCE #1	1983	50	P	Flash	SCE/
SCE #2	1986	100	P	Flash,	SCE/

SITE: Mono-Long Valley, Mono County, California

Mono-Long Valley is located east of the Sierra Nevada Mountains in an area of relatively constant seismic activity. The surrounding land is used primarily for recreational purposes with limited mining and agricultural activities. The area is sparsely populated. Official county reaction to development in this area is very positive however strong public opposition by various environmental groups has been voiced.

Development activity was initiated in the early 1970's with Chevron, Magma, and Geothermal Resources being the primary participants. Magma Power and SCE are currently developing a 20 MWe plant scheduled to be on line in 1985.

A controversy over leasing in the area is currently pending. Phillips Petroleum filed an appeal contending that specific provisions in the terms of a scheduled lease sale were unacceptable to industry. The argument centers on the small percentage of land being offered in the KGRA. USGS is reevaluating the stipulations, and the lease sale has been suspended until a decision is made.

SITE: Mono-Long Valley, Mono County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,920
Reservoir Area (sq. miles): ?
Temperature (°C): 227 (441°F)
Total Dissolved Solids (ppm): 1,000
Electric Energy Potential (MWe 30 years): 2,100

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	460,256
Acreage Leased	5,482	0	120	5,602

Major Lease Holders - Getty, City of Burbank,
Geothermal Resources

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	7	3	0	3

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	6	0	6	0

3. WELL DRILLING:

Total Wells Spudded: 37

Production: 1	Observation: 3
Injection: 0	Abandoned: 2
Exploratory: 0	Suspended: 0
Temperature Gradient: 30	Unknown: 1

Average Well Depth (ft): 1,362
Maximum Well Depth (ft): 6,494
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drillings by Year

	COMPANY						TOTAL
	REPUBLIC GEOTHERMAL	CHEVRON	MAGMA	GEOTHERMAL RESOURCES	USGS	UNION	
1970	1	6	1	1			9
1971					2		2
1975	6	16					22
1976	1						1
1979		1				2	3
TOTAL	8	23	1	1	2	2	37

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (1)	3-17-76

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
?	1985	20	P	Binary	SCE/Magma Power

SITE: Salton Sea/Niland Area, Imperial County, California

The Salton Sea/Niland Area is located in a seismically active area. The surrounding area is sparsely populated, with small population centers scattered throughout.

Well drillings occurred in the area as early as the 1920's, when shallow wells were drilled to obtain CO₂ for use in the manufacture of dry ice. Geothermal development began in approximately 1977 when Magma Power and Union Oil initiated exploratory activities. Four plants are scheduled to come on-line by 1985. SCE and Union Oil are developing two plants at this site. The SCE Pilot Plant will be 10 MWe and is scheduled for operation in July of 1982. The engineering and design contract for the plant was awarded to Fluor Power Company. The other SCE plant is still in the development stage. The remaining two plants are being developed by SDG&E and Magma Power. SDG&E #1 (flash, 26 MWe) is scheduled to come on line in 1983. SDG&E #2 (flash, 49 MWe) is scheduled for operation in 1985. This plant is currently in the application stage of development. An Environmental Impact Report (EIR) will be submitted by the end of the year.

SITE: Salton Sea/Niland Area, Imperial County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 1,640
 Reservoir Area (sq. miles): 23.3
 Temperature (°C): 323 (613°F)
 Total Dissolved Solids (ppm): 250,000
 Electric Energy Potential (MWe 30 years): 3,400

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	57,524	(81,820 combined)		139,344
Acres Leased	0	?	?	?

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	?	?	?	?

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	4	0	0	4

3. WELL DRILLING:

Total Wells Spudded: 58

Production: 10	Observation: 0
Injection: 1	Abandoned: 15
Exploratory: 0	Suspended: 12
Temperature Gradient: 0	Unknown: 20

Average Well Depth (ft): 4,226
 Maximum Well Depth (ft): 10,500
 Average Temperature (°F): 349
 Maximum Temperature (°F): 500
 Average Flow Rate (lbs/hr): ?

Well Drillings by Year

	COMPANY							
	MCCULLOCH	IMPERIAL THERMAL	GEO. ENERGY & MINERAL	UNION	REPUBLIC	MAGMA	PHILLIPS	TOTAL
1961		1	1					2
1963		2		1				3
1964			1	2				3
1965		1			2			3
1970	1				5		4	10
1972						5		5
1973					1			1
1974						1		1
1975				12				12
1976				11				11
1977		1						1
1978				1				1
1979				3	1			4
1980					2			2
TOTAL	1	5	2	30	11	6	4	59

4. PERMITTING INFORMATION:

Type
 APD's (20)
 AFC (SDG&E #2)
 EIR
 EAR

Date Approved/Completed

5-14-80
 Pending
 Pending
 10-78

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on- Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
SCE			P		SCE/Union Oil
SCE Pilot	1982	10	P		SCE/Union Oil
SDG&E #1	1983	26	P	Flash	SDG&E/Magma Power
SDG&E #2	1985	49	P	Flash	SDG&E/Magma Power

SITE: Surprise Valley, Modoc County, California

The Surprise Valley is located in a mountain valley which is sparsely populated. The towns of Cedarville and Lake City are within 20 miles of the resource. These are small towns with less than 1,000 inhabitants. Farming and lumbering are the two major commercial activities in the area. The water supply is very limited, and the water quality is poor, because it is highly alkaline.

Magma Power Company began geothermal drilling operations as early as 1959; Gulf Oil entered the search for the geothermal resource in the early 1970's. No power-on-line is envisioned for this area before 1990. Due to the varying temperature of the resource, it appears that direct heat applications may be more suitable if the resource is to be utilized.

SITE: Surprise Valley, Modoc County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,920
Reservoir Area (sq. miles): 49.5
Temperature (°C): 152 (306°F)
Total Dissolved Solids (ppm): 1,500
Electric Energy Potential (MWe 30 years): 1,490

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	126,720	115,200	0	241,920
Acreage Leased	8,880	0	0	8,880

Major Lease Holders - Eason, Mobil, Supron

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	16	5	4	1

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	42	5	34	3

3. WELL DRILLING:

Total Wells Spudded: 20

Production: 13	Observation: 0
Injection: 0	Abandoned: 1
Exploratory: 1	Suspended: 5
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 4,908
Maximum Well Depth (ft): 7,005
Average Temperature (°F): ?
Maximum Temperature (°F): 361
Average Flow Rate (lbs/hr): ?

Well Drillings by Year

	COMPANY			
	MAGMA	GULF	AMERICAN THERMAL	TOTAL
1960	2			2
1962	1			1
1973		2		2
1974	1		1	2
1975		5		5
1976		4		4
1977		4		4
TOTAL	4	15	1	20

4. PERMITTING INFORMATION:

Type

Date Approved/Completed

EAR

10-75

5. POWER PLANTS: None operational or proposed

SITE: Wendel-Amedee, Lassen County, California

The California Division of Water Resources (CDWR) and Geoproducts Inc. are preparing a cogeneration power plant design for the Wendel-Amedee site. Wood waste will be produced from lumber mills in the area 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 to the boiler and then to the wood waste fired boiler.

The reservoir and the 55 MWe plant will be operated by Geoproducts and CDWR will purchase the power. The waste steam from the plant will be used to warm greenhouses. If a viable resource is proven, plant construction will begin in 1983 with power-on-line scheduled for 1984.

SITE: Wendel-Amedee, Lassen County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 3,281
Reservoir Area (sq. miles): 2.4
Temperature (°C): 126 (259°F)
Total Dissolved Solids (ppm):
Electric Energy Potential (MWe 30 years): 500

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	17,292	0	0	17,292
Acreage Leased	3,756	0	0	3,756

Major Lease Holders - NONE IDENTIFIED

3. WELL DRILLING:

Total Wells Spudded: 5

Production: 0	Observation: 0
Injection: 0	Abandoned: 5
Exploratory: 0	Suspended: 0
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 2,816
Maximum Well Depth (ft): 5,056
Average Temperature (°F): ?
Maximum Temperature(°F): ?
Average Flow Rate (lbs/hr): ?

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on- Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
	1985	50	P	Hybrid	CDWR/Geoproducts

SITE: Westmorland, Imperial County, California

The Westmorland site lies in the Imperial Valley and may be an extension of the Salton Sea KGRA. Geothermal drilling operations were initiated in the mid 1970's by Republic Geothermal and in 1979 by Mapco Inc.

A proposed 48 MWe flash power plant is scheduled to begin operation in 1984. Two wells have already been drilled for this plant, and production flow testing is currently underway.

SITE: WESTMORLAND, CA

SITE: Westmorland, Imperial County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 3,609
Reservoir Area (sq. miles): 30.9
Temperature (°C): 217 (423°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 1710

2. LEASING: NONE IDENTIFIED

3. WELL DRILLING:

Total Wells Spudded: 10

Production: 8	Observation: 0
Injection: 0	Abandoned: 1
Exploratory: 0	Suspended: 1
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 7,516
Maximum Well Depth (ft): 10,456
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY		
	REPUBLIC	MAPCO	TOTAL
1975	2		2
1976	6		6
1979		1	1
1980		1	1
TOTAL	8	2	10

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (2)	2-80

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
	1984	48	P	Flash	Republic Geothermal

SITE: Puna (Kapoho Reservoir), Hawaii County, Hawaii

Puna is located in forested plains on the Island of Hawaii. The site is approximately 10 miles from the Pacific Ocean, in an extremely active seismic area. Very small population centers are located within a few miles of the site.

In the early 1960's, drilling to establish a geothermal resource was conducted by a New Zealand firm but proved to be unsuccessful. During this same period Magma Power also undertook drilling operations. The State of Hawaii and HELCO's 3 MWe HGP-A plant became operational in the fall of 1981. Thermal Power Company and Dillingham Corporation have joined together to pursue the development of a 25 MWe power plant scheduled to come on-line in 1988. Permits have been issued for exploratory wells, and drilling is underway.

SITE: KAPOHO RESERVOIR (PUNA), HI

SITE: Puna (Kapoho Reservoir), Hawaii County, Hawaii

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 7,218
Reservoir Area (sq. miles): 0.8
Temperature (°C): 275 (527°F)
Total Dissolved Solids (ppm): 2,000
Electric Energy Potential (MWe 30 years): 500

2. LEASING: NONE IDENTIFIED

3. WELL DRILLING:

Total Wells Spudded: 13

Production: 2	Observation: 3
Injection: 0	Abandoned: 0
Exploratory: 3	Suspended: 0
Temperature Gradient: 0	Unknown: 5

Average Well Depth (ft): 2,729
Maximum Well Depth (ft): 8,400
Average Temperature (°F): 538
Maximum Temperature (°F): 676
Average Flow Rate (lbs/hr): 84,000

Well Drilling by Year

	COMPANY					TOTAL
	HAWAII THERMAL	MAGMA	UNIVERSITY OF HAWAII	GEDCO	BARNWELL	
1961	3	4				7
1974	2					2
1975			1			1
1980				2		2
1981					1	1
TOTAL	5	4	1	2	1	13

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (4)	10-8-80
APD's (6)	1-81 (only 1 approved)

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
HGP-A	1981	3	O	Flash	Helco/State of Hawaii
	1988	25	P		Helco/Thermal Dillingham

SITE: Raft River, Cassia County, Idaho

The Raft River site is located in a relatively flat geographic area that is used almost exclusively for agriculture. The largest nearby town, Burley (pop. 8,000) is located 40 miles from the site.

This area was chosen to be the site of a pilot plant to demonstrate the reliability of binary power plants operating with low temperature geothermal fluids. The construction of this plant is complete but operational status has not been achieved. Lack of pumping equipment has delayed start-up operations. Proposed FY 1982 budget does not provide funding for the pilot plant.

SITE: Raft River, Cassia County, Idaho

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,264
Reservoir Area (sq. miles): 6.4
Temperature (°C): 149 (300°F)
Total Dissolved Solids (ppm): 2,000-5,000
Electric Energy Potential (MWe 30 years): 100

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	25,110	2,600	2,500	30,210
Acreage Leased	15,141	2,600	0	17,741

Major Lease Holders - Sunedco, Phillips, L. H. Armour

3. WELL DRILLING:

Total Wells Spudded: 18

Production: 6	Observation: 7
Injection: 5	Abandoned: 0
Exploratory: 0	Suspended: 0
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 5,022
Maximum Well Depth (ft): 6,562
Average Temperature (°F): 295
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY	
	DOE	TOTAL
1975	2	2
1976	3	3
1977	4	4
1978	9	9
TOTAL	18	18

4. PERMITTING INFORMATION: NONE IDENTIFIED

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on- Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
RR #1	?	5	P	Binary	DOE, INEL, EG&G

SITE: Beowawe, Eureka/Lander Counties, Nevada

The Beowawe site is located in a sparsely populated desert area. The closest town, Battle Mountain (pop. 2000), is roughly 20 miles from the site. A water shortage exists in the area.

Initial development activities began in the early 1960's with the drilling of numerous observation wells by Vulcan Thermal and Sierra Pacific. In the late 1970's Chevron began extensive exploration activities in the area. The reservoir seems capable of supporting electric production, but commercialization may be inhibited due to the remoteness of the site.

The site is being investigated by the NORNEV Consortium as being capable of producing 10 MWe during the early 1980's.

SITE: Beowawe, Eureka/Lander Counties, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 3,609
Reservoir Area (sq. miles): 2.0
Temperature (°C): 229 (444°F)
Total Dissolved Solids (ppm): 1,400
Electric Energy Potential (MWe 30 years): 127

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	0	33,225
Acreage Leased	17,051	0	0	17,051

Major Lease Holders - Getty, Chevron, Geothermal Resources

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	8	6	0	6

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING:

Total Wells Spudded: 22

Production: 3	Observation: 16
Injection: 0	Abandoned: 0
Exploratory: 2	Suspended: 1
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 3,819
Maximum Well Depth (ft): 9,564
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY				
	VULCAN THERMAL	SIERRA PACIFIC	CHEVRON	AMAX EXPLORATION	TOTAL
1961	6				6
1964		4			4
1974			1		1
1979			5		5
1980			3	1	4
TOTAL	6	4	9	1	20

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (2)	1-14-80

5. POWER PLANTS: None operational but the site is being investigated as a candidate for a 10 MWe.

SITE: Brady H.S., Churchill County, Nevada

The topography of the Brady Hot Springs Site consists of alkali flats, dry washes and buttes. There is no surface water available. Land use at present consists of agricultural and recreational activities. The town of Fernley (pop. 1000), the closest population center, is roughly 20 miles away. Reno (pop. 70,000) is within 50 miles of the site.

Limited drilling was undertaken throughout the mid and late 1970's by Magma Power and Phillips Petroleum. No electric power plants are being considered in the near terms.

SITE: Brady H.S., Churchill County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 3,280
Reservoir Area (sq. miles): 5.0
Temperature (°C): 155 (311°F)
Total Dissolved Solids (ppm): 2,450
Electric Energy Potential (MWe 30 years): 157

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	59,358	(39,150 combined)		98,508
Acres Leased	43,248	0	0	43,248

Major Lease Holders - Phillips, Supron Energy, Geothermal Resources, Southern Union

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	26	19	4	15

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING:

Total Wells Spudded: 22

Production: 3
Injection: 1
Exploratory: 0
Temperature Gradient: 0

Observation: 16
Abandoned: 1
Suspended: 1
Unknown: 0

Average Well Depth (ft): 2,392
Maximum Well Depth (ft): 7,661
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY			
	MAGMA	EARTH ENERGY	PHILLIPS	TOTAL
1960	12			12
1964		2		2
1965		1		1
1974	1		1	2
1975	3			3
1976			2	2
TOTAL	16	3	3	22

4. PERMITTING INFORMATION:

Type

Date Approved/Completed

EAR

7-7-74

5. POWER PLANTS: None operational or proposed

SITE: Desert Peak, Churchill County, Nevada

Relatively limited development activity has occurred at Desert Peak. Phillips Petroleum has drilled a small number of exploratory wells. The site is one of five being considered by the NORNEV Consortium as being capable of supporting electric power generation.

SITE: DESERT PEAK, NV

SITE: Desert Peak, Churchill County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 11.6
Temperature (°C): 221°C (430°F)
Total Dissolved Solids (ppm): 6,000-8,000
Electric Energy Potential (MWe 30 years): 750

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	59,358	(39,150 combined)		98,508
Acres Leased	?	?	?	?

Major Lease Holders - None Identified

3. WELL DRILLING:

Total Wells Spudded: 4

Production: 0	Observation: 0
Injection: 0	Abandoned: 0
Exploratory: 4	Suspended: 0
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft):
Maximum Well Depth (ft):
Average Temperature (°F):
Maximum Temperature (°F):
Average Flow Rate (lbs/hr):

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Valles Caldera (Baca), Sandoval County, New Mexico

Valles Caldera is located in a generally mountainous region. It is a caldera area that may still be in a stage of collapse. The area within the caldera is primarily private land. The site is bordered on three sides by National Forest land and on the fourth side by the Santa Clara Indian Reserve. The nearest population center is the town of Bernadillo (pop. 2500), which is ten miles away.

Interest in geothermal development in this area occurred in 1963 when an oil and gas exploratory well hit geothermal fluids. In 1968, Baca Ranch made an agreement with Union Oil to develop the geothermal resource. In 1971 Union initiated drilling activities and is continually evaluating the resource. The site was selected by DOE for a cost-sharing agreement to develop the reservoir.

Phillips Petroleum and Public Services Corporation of New Mexico (PNM) are developing the reservoir; a 50 MWe flash power plant is scheduled to begin operation in 1983.

SITE: Valles Caldera (Baca), Sandoval County, New Mexico

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 3,281
Reservoir Area (sq. miles): 29.0
Temperature (°C): 139 (273°F)
Total Dissolved Solids (ppm): 4,500
Electric Energy Potential (MWe 30 years): 2,700

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	358,189	(138,761 combined)		496,950
Acres Leased	25,625	0	0	25,625

Major Lease Holders - Union, Amax, Phillips, Aminoil

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinqu.</u>	<u>Existing Leases Tracts</u>
Competitive Leasing	17	15	0	15

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	29	0	0	29

3. WELL DRILLING:

Total Wells Spudded: 23

Production: 11	Observation: 0
Injection: 2	Abandoned: 0
Exploratory: 7	Suspended: 0
Temperature Gradient: 0	Unknown: 3

Average Well Depth (ft): 5,980
Maximum Well Depth (ft): 7,001
Average Temperature (°F): ?
Maximum Temperature (°F): ??
Average Flow Rate (lbs/hr): 126,000

Well Drilling by Year

	COMPANY		
	UNION	LASL	TOTAL
1970	3		3
1971	1		1
1972	1	1	2
1973	2		2
1974	3	1	4
1975	2	2	4
1979	2		2
1980	4		4
1981	1		1
TOTAL	19	4	23

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on-Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
BACA #1	1983	45	P	Flash	PNM/Union Oil

SITE: Crump's H.S., Lake County, Oregon

Crump's Hot Springs is situated in the Basin and Range area of Oregon which extends across the southern portion of the state. Population centers in proximity to the site are generally small, having less than 500 inhabitants.

Numerous wells have been drilled in the area primarily by Chevron. Testing of the resource has indicated that reservoir temperature may be inadequate for electric power generation. Development of the site is not expected to occur in the near term.

SITE: CRUMP'S HOT SPRINGS, OR

SITE: Crump's H.S., Lake County, Oregon

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,920
Reservoir Area (sq. miles): 1.5
Temperature (°C): 167 (333°F)
Total Dissolved Solids (ppm): 668
Electric Energy Potential (MWe 30 years): 61

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	315,000	(90,000 combined)		405,000
Acreage Leased	44,279	0	0	44,279

Major Lease Holders - Chevron, Hunt Family

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	22	10	0	10

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	45	17	15	13

3. WELL DRILLING:

Total Wells Spudded: 4

Production: 0
Injection: 0
Exploratory: 2
Temperature Gradient: 1

Observation: 0
Abandoned: 0
Suspended: 0
Unknown: 1

Average Well Depth (ft): 1,615
Maximum Well Depth (ft): 1,730
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY			
	SAN JUAN OIL	CHEVRON	NEVADA THERMAL	TOTAL
1975	1		1	2
1978		1		1
1980		1		1
TOTAL	1	2	1	4

4. **PERMITTING INFORMATION:**

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (2)	9-6-74
APD's (2)	7-8-75
APD's (1)	7-30-75

5. **POWER PLANTS:** None operational or proposed

SITE: Vale H.S., Malheur County, Oregon

The Vale Hot Springs site is characterized by a topography of desert shrubland. It is colocated with the city of Vale (pop. 2000). In the late 1970's numerous exploratory and temperature gradient wells were drilled by Chevron and Republic Geothermal. Until recently, no other development activity had been undertaken. In June of this year, Amax exploration drilled a series of temperature gradient wells at the site. Although this new drilling activity indicates a renewed interest in the area, electric power generation is not expected to occur in the near term.

SITE: Vale H.S., Malheur County, Oregon

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,920
Reservoir Area (sq. miles): 27.0
Temperature (°C): 157 (315°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 870

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	0	8,433	?
Acres Leased	25,296	0	0	25,296

Major Lease Holders -

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	7	7	0	7

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING:

Total Wells Spudded: 18

Production: 0	Observation: 0
Injection: 0	Abandoned: 1
Exploratory: 3	Suspended: 0
Temperature Gradient: 14	Unknown: 0

Average Well Depth (ft): 835
Maximum Well Depth (ft): 2,822
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY			
	CHEVRON	REPUBLIC	AMAX	TOTAL
1978	3			3
1979	1	10		11
1981			4	4
TOTAL	4	10	4	18

4. PERMITTING INFORMATION:

Type

Date Approved/Completed

EAR

4-74

5. POWER PLANTS: None operational or proposed

SITE: Roosevelt H.S., Beaver County, Utah

Roosevelt Hot Spring is located in a desert-type environment bordered by mountains. The towns of Milford (pop. 1500) and Beaver (pop. 1600) are the nearest population centers and are less than 20 miles away. The attitude of the public is very positive toward geothermal development.

Drilling activity at the site has been primarily conducted by Phillips Petroleum since the mid 1970's. Over 40 wells have been spudded since that time.

Phillips Petroleum and Utah Power and Light have agreed to develop three power plant units at the site. UP&L #1 will be a 20 MWe flash plant scheduled to come on line in 1983. Field site and transmission line applications were filed with BLM and USGS in January, 1981. An Environmental Assessment Report (EAR) is expected in the fall of this year. The engineering design contractor for the plant is Gibbs and Hill. UP&L #2 and #3 are subsequent units planned under the previous agreement. These units are scheduled for 1987.

SITE: Roosevelt H.S., Beaver County, Utah

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,264
Reservoir Area (sq. miles): 9.1
Temperature (°C): 265 (509°F)
Total Dissolved Solids (ppm): 7,800
Electric Energy Potential (MWe 30 years): 970

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	43,453	2,482	2,864	48,799
Acreage Leased	37,386	2,482	2,553	42,421

Major Lease Holders - Phillips, Geothermal Exploration,
Trevall L. Windsor, Union

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	14	14	1	13

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	61	19	36	6

3. WELL DRILLING:

Total Wells Spudded: 41

Production: 6
Injection: 2
Exploratory: 7
Temperature Gradient: 7

Observation: 12
Abandoned: 1
Suspended: 5
Unknown: 1

Average Well Depth (ft): 5,735
Maximum Well Depth (ft): 12,646
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY					
	UNIVERSITY OF UTAH	PHILLIPS	THERMAL POWER	GETTY	MCCULLOUGH	TOTAL
1974	5					5
1975		18				18
1976		2	2			4
1977		5				5
1978		5	1	2		8
1979					1	1
TOTAL	5	30	3	2	1	41

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
EAR	6-74
APD's (3)	1-24-75
APD's (1)	4-1-75
APD's (1)	6-10-75
APD's (1)	7-15-75
APD's (1)	9-12-75
APD's (5)	7-9-76
APD's (1)	5-12-77
APD's (1)	5-11-79

5. POWER PLANTS:

<u>Plant Name</u>	<u>Year-on- Line</u>	<u>MWe</u>	<u>Status</u>	<u>Type</u>	<u>Utility/Developer</u>
UP&L #1	1983	20	P	Flash	UP&L/Phillips Petroleum
UP&L #2			P	Flash	UP&L/Phillips Petroleum
UP&L #3			P		UP&L/Phillips Petroleum

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Known Geothermal Resource Areas With Moderate Levels of Developmental Activity

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SITE: Lassen, Tehema County, California

The Lassen site is located in the Cascade Mountain Range. Public opposition to development has arisen due to the scenic quality of the land.

In the late 1970's Phillips Petroleum began well drilling to evaluate the site's potential. There has been no other significant development activity. A recent "Declaration by Taking" order issued by the U.S. Congress has restricted Lassen Park from geothermal development. The justification for the order was the potential adverse effects of development on nearby geysers and hot springs. There is still a possibility that exploration and drilling may be allowed near the park. Further development of this site appears to be completely prohibited or at best severely inhibited.

SITE: LASSEN, CA

SITE: Lassen, Tehema County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 3,281
Reservoir Area (sq. miles): 1.9
Temperature (°C): 240 (464°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 133

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	80,492	(24,002 combined)		104,494
Acres Leased	?	?	?	?

3. WELL DRILLING:

Total Wells Spudded: 3

Production: 0	Observation: 1
Injection: 0	Abandoned: 0
Exploratory: 2	Suspended: 0
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): ?
Maximum Well Depth (ft): 4,099
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY	
	PHILLIPS	TOTAL
1977	2	2
1978	1	1
TOTAL	3	3

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Crane Creek/Cove Creek, Washington County, Idaho

The site is located on the Weiser River near the Crane Creek Reservoir. The surrounding topography is basically open areas positioned between low mountains. The town of Midvale (pop. 5800) is located within 20 miles of the site.

Phillips Petroleum has drilled a few exploratory wells in the area but the resource has not yet been confirmed. No electric power production can be expected prior to 1990.

SITE: Crane Creek/Cove Creek, Washington County, Idaho

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 9.0
Temperature (°C): 171 (340°F)
Total Dissolved Solids (ppm): 1,070
Electric Energy Potential (MWe 30 years): 340

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	60,000	640	462	61,102
Acreage Leased	9,459	640	0	10,099

Major Lease Holders - Sunedco, Supron, Phillips, Union

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	1	1	0	1

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	19	13	0	6

3. WELL DRILLING:

Total Wells Spudded: 3

Production: 0	Observation: 0
Injection: 0	Abandoned: 0
Exploratory: 2	Suspended: 1
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 3,934
Maximum Well Depth (ft): 8,002
Average Temperature (°F): ?
Maximum Temperature(°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY	
	PHILLIPS	TOTAL
1976	2	2
1977	1	1
TOTAL	3	3

4. PERMITTING INFORMATION:

Type

Date Approved/Completed

EAR

2-78

5. POWER PLANTS: None operational or proposed

SITE: Dixie H.S., Churchill County, Nevada

Limited development activity has occurred at this site. From 1978 to the present, Republic Geothermal, Thermal Power, and Sunedco have drilled a total of 12 wells. The site is one of five being investigated by the NORNEV consortium for location of a 10 MWe plant.

SITE: DIXIE HOT SPRINGS, NV

SITE: Dixie H.S., Churchill County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 5,577
Temperature (°C): 139 (282°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): ?

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	0	0	?
Acreage Leased	168,438	0	0	168,438

Major Lease Holders - UNKNOWN

3. WELL DRILLING:

Total Wells Spudded: 12

Production: 3	Observation: 4
Injection: 0	Abandoned: 0
Exploratory: 0	Suspended: 3
Temperature Gradient: 1	Unknown: 1

Average Well Depth (ft): 7,832
Maximum Well Depth (ft): 12,500
Average Temperature (°F): ?
Maximum Temperature(°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY			
	SUNEDCO	REPUBLIC GEOTHERMAL	THERMAL POWER	TOTAL
1978	1	1	-	2
1979	2		2	4
1980	3	2		5
1981	1			1
TOTAL	7	3	2	12

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (5)	8-8-79
APD's (3)	10-18-79

5. POWER PLANTS: None operational or proposed

SITE: Humboldt House, Pershing County, Nevada

The Humboldt House site has received only moderate development activity. Through the late 1970's Phillips Petroleum spudded three wells at the location. Preliminary results indicate that the site may have good production potential. There has been almost no activity at the site during the past year. While the production potential appears good it is not anticipated that power-on-line will occur prior to the 1990's.

SITE: Humboldt House, Pershing County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 0.8
Temperature (°C): 217 (423°F)
Total Dissolved Solids (ppm): 6,000
Electric Energy Potential (MWe 30 years): 47

2. LEASING: NONE IDENTIFIED

3. WELL DRILLING:

Total Wells Spudded: 3

Production: 0

Injection: 0

Exploratory: 0

Temperature Gradient: 1

Observation: 0

Abandoned: 0

Suspended: 1

Unknown: 1

Average Well Depth (ft): 5,503

Maximum Well Depth (ft): 8,081

Average Temperature (°F): ?

Maximum Temperature(°F): ?

Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY	
	PHILLIPS	TOTAL
1977	1	1
1978	1	1
1979	1	1
TOTAL	3	3

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: San Emedio Desert Area, Washoe County, Nevada

The site has seen only very limited development activity. Chevron has drilled a few observation wells in the area but the results are not encouraging. In conversations with the developer, there is a feeling that the site will develop for direct heat applications. It appears highly doubtful that the site will be utilized for electric power generation.

SITE: SAN EMEDIO DESERT AREA, NV

SITE: San Emedio Desert Area, Washoe County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 0.8
Temperature (°C): 166 (331°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 28

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	?
Acres Leased	8,352	?	?	?

Major Lease Holders - Phillips Petroleum, Geothermal Resources, Chevron

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	3	1	0	1

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING:

Total Wells Spudded: 2

Production: 0	Observation: 2
Injection: 0	Abandoned: 0
Exploratory: 0	Suspended: 0
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 4,690
Maximum Well Depth (ft): 5,367
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY	
	CHEVRON	TOTAL
1975	1	1
1978	1	1
TOTAL	2	2

4. PERMITTING INFORMATION: None identified
5. POWER PLANTS: None operational or proposed

SITE: Soda Lake, Churchill County, Nevada

Chevron has been the major developer at this site. From 1974 to present, Chevron has drilled approximately one well a year. The results of these drilling efforts have not been encouraging. Additionally, there is a lack of available surface water. Further development at this site is not anticipated until the 1990s.

SITE: SODA LAKE AREA, NV

SITE: Soda Lake, Churchill County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): ?
Reservoir Area (sq. miles): ?
Temperature (°C): 157°C (315°F)
Total Dissolved Solids (ppm):
Electric Energy Potential (MWe 30 years): 146

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	?
Acreage Leased	8,881	?	?	8,881

Major Lease Holders - Phillips

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	3	1	0	1

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING:

Total Wells Spudded: 5

Production: 0	Observation: 1
Injection: 0	Abandoned: 0
Exploratory: 0	Suspended: 2
Temperature Gradient: 2	Unknown: 0

Average Well Depth (ft): 3,355
Maximum Well Depth (ft): 4,974
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY	
	CHEVRON	TOTAL
1974	1	1
1977	1	1
1978	1	1
1979	1	1
1980	1	1
TOTAL	5	5

4. PERMITTING INFORMATION:

<u>Type</u>	<u>Date Approved/Completed</u>
APD's (1)	10-13-77
APD's (2)	12-21-78
APD's (1)	12-27-79

5. POWER PLANTS: None operational or proposed

SITE: Steamboat Springs, Washoe County, Nevada

The site is located in a mountainous region with many man-made intrusions. It is also situated in the Virginia City mining district. Steamboat Springs has been used as a resort area for many years. Additionally, there are plans to develop the area for residential use. Community reaction to geothermal development has been generally negative since the area is used for numerous recreational activities. The city of Reno (pop. 120,000) is located only 12 miles away.

Leasing activity at the site has been relatively vigorous with Phillips, Chevron, Gulf, Al Aquitane, and Hunt Oil being the major leaseholders. USGS has drilled a number of observation wells in the area; Phillips Petroleum has also participated in drilling to a lesser extent. Developers at the site have expressed a need for reliable downhole pumps capable of operating at a temperature of 260°C.

The NORNEV Consortium is evaluating the site for construction of a 10 MWe power plant.

SITE: Steamboat Springs, Washoe County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 984
Reservoir Area (sq. miles): 4.5
Temperature (°C): 200 (392°F)
Total Dissolved Solids (ppm): 3,000
Electric Energy Potential (MWe 30 years): 350

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	888,600	(592,400 combined)		1,481,000
Acreage Leased	26,233	0	0	26,233

Major Lease Holders - Phillips, Geothermal Resources, Gulf,
Sulphur River Exploration

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	2	2	0	2

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	42	14	27	1

3. WELL DRILLING:

Total Wells Spudded: 15

Production: 1
Injection: 0
Exploratory: 0
Temperature Gradient: 0

Observation: 14
Abandoned: 0
Suspended: 0
Unknown: 0

Average Well Depth (ft): 1,967
Maximum Well Depth (ft): 3,073
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY			
	NEVADA THERMAL	USGS	PHILLIPS	TOTAL
1960	2			2
1961	2			2
1962	2			2
1978		8		8
1979			1	1
TOTAL	6	8	1	15

4. PERMITTING INFORMATION: None identified
5. POWER PLANTS: None operational or proposed

SITE: Stillwater Area, Churchill County, Nevada

The site is located in proximity to the Soda Lake Area and both are likely part of the same geothermal resource. Union Oil, Chevron, and Phillips are the major lease holders in the area. Union Oil has been the primary participant in well drilling activity at the site. Results of well drilling activities have been 168°C with a maximum of 212°C achieved. Average flow rates have been 150,000 lbs./hr.

It appears that the site has the potential to support electric power generation, but it is not expected to occur in the near term.

SITE: Stillwater Area, Churchill County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 3,281
Reservoir Area (sq. miles): 13.6
Temperature (°C): 157 (315°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 450

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	0	225,260
Acreage Leased	8,361	0	0	8,361

Major Lease Holders - Union Oil, Chevron, Phillips

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	22	6	3	6*

* tract offered more than once

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING:

Total Wells Spudded: 5

Production: 1	Observation: 1
Injection: 0	Abandoned: 0
Exploratory: 2	Suspended: 1
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 6,139
Maximum Well Depth (ft): 9,641
Average Temperature (°F): 328
Maximum Temperature (°F): 414
Average Flow Rate (lbs/hr): 150,000

Well Drilling by Year

	COMPANY		
	UNION	PHILLIPS	TOTAL
1976	3		3
1979	1	1	2
TOTAL	4	1	5

4. PERMITTING INFORMATION: None identified
5. POWER PLANTS: None operational or proposed

SITE: Alvord, Harney County, Oregon

Alvord is located in a very remote area with extremely rough terrain and steep mountain slopes. The population within 50 miles of the site is less than 100 individuals. Environmental groups have expressed negative feelings toward development of the area. Anadarko has drilled several exploratory wells in the area and this is the only activity noted.

Due to the remoteness of the area and opposition from environmental groups, development of the site does not appear likely.

SITE: Alvord, Harney County, Oregon

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 1.2
Temperature (°C): 181 (358°F)
Total Dissolved Solids (ppm): 1,400
Electric Energy Potential (MWe 30 years): 49

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	106,438	5,360	64,575	176,373
Acreage Leased	25,398	2,800	41,500	69,698

Major Lease Holders - Al Aquitaine, Exploration, Anadarko, Hunt
Oil, Supron

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	46	20	10	10

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING:

Total Wells Spudded: 6

Production: 0	Observation: 0
Injection: 0	Abandoned: 0
Exploratory: 5	Suspended: 0
Temperature Gradient: 1	Unknown: 0

Average Well Depth (ft): 1,500
Maximum Well Depth (ft): 2,000
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY			
	ANADARKO	CHEVRON	UNION	TOTAL
1979	3	2	1	6
TOTAL	3	2	1	6

4. PERMITTING INFORMATION: None Identified
5. POWER PLANTS: None operational or proposed

SITE: Cove Fort/Sulphurdale, Millard and Beaver Counties, Utah

The Cove Fort/Sulphurdale site is situated in an area characterized by forests and low mountainous terrain. It is adjacent to the Fishlake National Forest. The resource is within 25 miles of three population centers, namely Manderfield, Beaver, and Hanosh with a combined population of under 15,000. Minor seismic activity has occurred in the surrounding area. It is possible that the site may be an extension of the Roosevelt Hot Springs System.

Approximately 70,000 acres of federal land at the site has been leased. Major leaseholders include Phillips Petroleum, Amax Exploration, and the Hunt Family. Union Oil has been the most active in drilling operations at the site, but has ceased operations, citing unattractive costs.

Development of this site is not expected to occur before the 1990's.

SITE: Cove Fort/Sulphurdale, Millard and Beaver Counties, Utah

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 9.3
Temperature (°C): 167 (333°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 330

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	79,071	3,815	0	82,886
Acreage Leased	74,766	0	0	74,766

Major Lease Holders -

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	12	12	1	11

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	63	22	40	1

3. WELL DRILLING:

Total Wells Spudded: 7

Production: 0	Observation: 1
Injection: 0	Abandoned: 1
Exploratory: 3	Suspended: 2
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 4,205
Maximum Well Depth (ft): 8,000
Average Temperature (°F): 335
Maximum Temperature(°F): 335
Average Flow Rate (lbs/hr): ?

Well Drilling by Year

	COMPANY			
	PHILLIPS	UNION OIL	HUNT OIL	TOTAL
1975	1			1
1976		1		1
1977		2		2
1978		2	1	3
1979		1		1
TOTAL	1	6	1	8

4. PERMITTING INFORMATION:

Type

Date Approved/Completed

EAR
APD's (3)
APD's (1)
APD's (1)

1-75
7-25-77
9-26-77
11-2-78

5. POWER PLANTS: None operational or proposed

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SITE: Bailey Bay H.S., Alaska

The site is located about 50 air miles north of Ketchikan, off the Behm Canal. The site is accessible only by float plane and the access to the area is unsuitable for vehicular traffic. The land in the immediate vicinity is the Tongass National Forest; development at this location is generally discouraged. Avalanches have been noted in the area as well as high seismic activity.

Very little development activity has occurred at this site. Due to the remoteness and unaccessibility of the site it is not likely that the development of electric power will occur.

SITE: BAILEY BAY HOT SPRINGS, AK

SITE: Bailey Bay H.S., Alaska

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 0.8
Temperature (°C): 164 (327°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 26

2. LEASING: None identified

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Geyser Bight, Alaska

The site is located on Unmak Island, roughly 600 miles from Anchorage in the eastern Aleutian Islands. The nearest population center is the village of Nikolski (pop. 50) 30 miles away. The area is one of high volcanic and seismic activity.

The resource is most capable of producing electricity. The only problem is who would use it. It appears that a more likely utilization of the resource would be for direct heat applications.

SITE: GEYSER BIGHT, AK

SITE: Geyser Bight, Alaska

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 2.4
Temperature (°C): 208 (406°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 136

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	20,960	0	0	20,960
Acreage Leased	0	0	0	0

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Hot Springs Cove, Alaska

The site is located on the beach at Inanudak Bay on Umnak Island. At present there is no population in the area. The area has both high volcanic and seismic activity.

Public interest is very high for developing this area. The use of the resource however will be for direct heat application such as fish hatcheries and greenhouses.

SITE: HOT SPRINGS COVE, AK

SITE: Hot Springs Cove, Alaska

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 0.8
Temperature (°C): 162 (324°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 27

2. LEASING: None identified

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	0	0	11,000	11,000
Acreage Leased	0	0	0	0

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Power Ranches Inc., Wells, Maricopa, Arizona

The site is located in the Basin and Range Province of Arizona. There has been almost no development activity in this area for electric power generation. Geothermal Kinetics drilled a series of test wells from 1973 through 1975. It appears that electric power generation is not likely, although direct heat applications may become very prevalent.

SITE: POWER RANCHES, AZ

SITE: Power Ranches Inc., Wells, Maricopa, Arizona

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 8,200
Reservoir Area (sq. miles): ?
Temperature (°C): 165 (329°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 23

2. LEASING: None identified

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Border, Imperial County, California

The site is situated in the Imperial Valley and is likely to be an extension of the vast geothermal system which dominates this area. No development activity at this site has been undertaken.

SITE: BORDER, CA

SITE: Border, Imperial County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 7,544
Reservoir Area (sq. miles): ?
Temperature (°C): 160 (320°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 31

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	31,100	0	2,080	33,180
Acreage Leased	0	0	0	0

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	0	0	0	0

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	31	0	28	3

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Clear Lake, California

The site is located in close proximity to the Geysers Complex. Accelerated exploration of steam resources in that area has diverted attention and resources from the development of this site. Near term development is certainly not a possibility at this time.

SITE: Clear Lake, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 19.3
Temperature (°C): 190 (374°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 900

2. LEASING: None identified

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Morgan Springs/Growler Springs, Tekema County, California

The site is located in close proximity to the geothermal system at Lassen and is very likely an extension of this system. No development activity has taken place and electric power generation is not anticipated.

SITE: MORGAN SPRINGS - GROWLER SPRINGS, CA

SITE: Morgan Springs/Growler Springs, Tekema County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 1.9
Temperature (°C): 217 (423°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 116

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	80,492	?	?	104,494
Acreage Leased	0	0	0	0

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	0	0	0	0

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	28	0	28	0

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Randsburg, San Bernadino County, California

Almost no development activity has occurred at this site. One well has been drilled to a depth of 235 m with a reported temperature of 115°C. Development at this site is not likely.

SITE: RANDSBURG, CA

SITE: Randsburg, San Bernadino County, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 3,281
Reservoir Area (sq. miles): 2.2
Temperature (°C): 172 (342°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 84

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	84,787	0	1,233	86,020
Acreage Leased	5,478	0	0	5,478

Major Lease Holders - Getty, Magma

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	0	0	0	0

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	34	0	10	24

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Sulphur Bank Mine, California

The site is located in the Clear Lake Area and has experienced minimal development activity. Accelerated exploration of steam resources at the Geysers has diverted attention and resources from this area. Development of this area prior to the 1990's is not likely to occur.

SITE: SULPHUR BANK MINE, CA

SITE: Sulphur Bank Mine, California

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 1.5
Temperature (°C): 194 (381°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 75

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	82,419	0	0	378,687
Acreage Leased	14,801	0	0	14,801

Major Lease Holders - Shell, Thermogenics, Union, Magma

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	14*	23	0	23

* Tract offered more than once

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	217	0	200	17

3. WELL DRILLING:

Total Wells Spudded: 4

Production: 1	Observation: 1
Injection: 0	Abandoned: 1
Exploratory: 1	Suspended: 0
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 5,138
Maximum Well Depth (ft): 8,000
Average Temperature (°F): 266
Maximum Temperature (°F): 266
Average Flow Rate (lbs/hr): ?

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Paradise H.S., Colorado

Only limited leasing and well drilling has occurred. Temperatures do not seem sufficient to support electric power generation. It is very unlikely that this site will be developed.

SITE: PARADISE HOT SPRINGS, CO

SITE: Paradise H.S., Colorado

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 154 (309°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 24

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	?
Acreage Leased	1,200	?	?	1,200

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Kamaili Homestead, Hawaii

At the present time, no development has occurred at this site. The area is also one of high seismic activity. Recent successes at the Puna site have also diverted attention from this area. Electric power development at this site will depend on further successes at Puna.

SITE: KAMAILI HOMESTEADS, HI

SITE: Kamaili Homestead, Hawaii

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,920
Reservoir Area (sq. miles): ?
Temperature (°C): 273 (523°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 210

2. LEASING: None identified

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Big Creek H.S., Lemi County, Idaho

No development in this area.

SITE: BIG CREEK HOT SPRINGS, ID

SITE: Big Creek H.S., Lemi County, Idaho

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 162 (324°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 26

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	7,500	0	0	7,500
Acreage Leased	0	0	0	0

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Baltazor H.S., Humboldt County, Nevada

The only activity at this site has been a relatively high level of leasing. Major leaseholders include U.S. Geothermal, Earth Power, and Union Oil. Long range development is still feasible.

SITE: BALTAZOR HOT SPRINGS, NV

SITE: Baltazor H.S., Humboldt County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 1.5
Temperature (°C): 158 (316°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 46

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	?
Acres Leased	239,000	?	?	239,000

Major Lease Holders - U.S. Geothermal, Earth Power, Union

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	3	3	0	3

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	275	107	143	25

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Fernley, Lyone County, Nevada

The only activity at this site has been the utilization of geothermal energy for direct applications. Electric power development does not appear likely.

SITE: FERNLEY, NV

SITE: Fernley, Lyone County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 0.8
Temperature (°C): 182 (360°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 33

2. LEASING: None identified

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Great Boiling (Gerlach), Washoe County, Nevada

The site has experienced limited leasing and drilling activity. Major leaseholders include Occidental, Sunedco, Chevron, and Union Oil. Sunedco has drilled exploratory wells in the area. Near-term development seems unlikely.

SITE: GREAT BOILING SPRINGS (GERLACH), NV

SITE: Great Boiling (Gerlach), Washoe County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 0.8
Temperature (°C): 178 (352°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 32

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	1,370,349	?	86,651	1,475,000
Acres Leased	61,542	?	0	61,542

Major Lease Holders - Eason, Supron, Occidental, Union

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	11	7	1	6

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	272	40	221	6

3. WELL DRILLING:

Total Wells Spudded: 1

Production: 0	Observation: 0
Injection: 0	Abandoned: 0
Exploratory: 1	Suspended: 0
Temperature Gradient: 0	Unknown: 0

Average Well Depth (ft): 5,869
Maximum Well Depth (ft): 5,869
Average Temperature (°F): ?
Maximum Temperature (°F): ?
Average Flow Rate (lbs/hr): ?

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Hot Sulphur Springs (Tuscarora), Elko County, Nevada

Very little leasing or drilling has occurred at this site. Major leaseholders include Getty Oil, Chevron, Mobil, and Union. Although very few wells have been drilled, consistently low flow rates have been noted. The site does not appear to have significant potential for development in the near-term.

SITE: Hot Sulphur Springs (Tuscarora), Elko County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 165 (329°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 27

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	86,651	45,000
Acreage Leased	34,899	?	?	34,899

Major Lease Holders - Getty, Mobil, Chevron, Geothermal Resources

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	1	1	0	1

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	63	26	27	10

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

<u>Type</u>	<u>Date Approved/Completed</u>
APD'S (1)	2-18-78

5. POWER PLANTS: None operational or proposed

SITE: Kyle H.S., Pershing County, Nevada

Extremely limited development activity has occurred at this site. Approximately 15,000 acres of land have been leased primarily to private individuals. A few wells have been drilled and preliminary results have not confirmed the viability of the resource.

Currently, there are a few direct heat applications in the general area of the reservoir. The development of electric power at this site is not likely before the end of the century.

SITE: Kyle H.S., Pershing County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): 1.9
Temperature (°C): 159 (318°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 97

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	?
Acreage Leased	15,149	?	?	15,149

Major Lease Holders - Chevron, Roger Millican

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	2	2	0	2

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Leach, Pershing County, Nevada

The site is situated in a mountainous area which has experienced seismic activity. The area is sparsely populated with less than 100 individuals living within 30 miles of the site. In the late 1970's a reasonably high level of leasing activity was initiated. Aminoil was the principal lessee along with many private individuals.

Two wells have been drilled at the site but were abandoned as non-productive. It appears likely that the site may be best utilized for direct heat applications.

SITE: Leach, Pershing County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 2.2
Temperature (°C): 162 (324°F)
Total Dissolved Solids (ppm): 2000
Electric Energy Potential (MWe 30 years): 77

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	551	?
Acreage Leased	40,127	?	0	40,127

Major Lease Holders - Aminoil, Mr. G. Martin Booth, Mr. Sidney E. Glenn

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	5	5	0	5

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Lee H.S., Churchill County, Nevada

A large amount of leasing activity has taken place at this site. Primary leaseholders include Geothermal Resources, Mobil Oil, Republic Geothermal and Phillips. The area is located in a wilderness setting which due to economic considerations does not make the site promising for near-term development.

SITE: LEE HOT SPRINGS, NV

SITE: Lee H.S., Churchill County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 166 (331°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 28

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	?
Acreage Leased	347,656	?	?	347,656

Major Lease Holders - Geothermal Resources, Mobil, Union,
Republic

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	0	0	0	0

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	446	169	268	8

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Pinto H.S., Humboldt County, Nevada

Very limited development activity has occurred at the site. Four leases have been issued with Union Oil being the major leaseholder. Near-term development is not anticipated.

SITE: PINTO HOT SPRINGS, NV

SITE: Pinto H.S., Humboldt County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 178 (352°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 32

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	?
Acreage Leased	8,015	?	?	8,015

Major Lease Holders - Union, Mr. C. Sampson

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	4	4	0	4

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Sulphur H.S., Elko County, Nevada

No development activity has taken place. Electric power generation is not likely before the end of the century.

SITE: SULPHUR HOT SPRINGS, NV

SITE: Sulphur H.S., Elko County, Nevada

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 178 (352°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 74

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	?	?	?	?
Acreage Leased	3,823	?	?	3,823

Major Lease Holders - None identified

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	4	4	2	2

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	0	0	0	0

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Hot (Borax) Lake Area, Harney County, Oregon

At present no development activity has occurred in this area. The Oregon Snail Darter which is an endangered species has been found in the area which has resulted in the U.S. Fish and Wildlife Service initiating actions preventing development. Geothermal development is not likely to occur at this site.

SITE: Hot (Borax) Lake Area, Harney County, Oregon

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 4,921
Reservoir Area (sq. miles): 1.9
Temperature (°C): 191 (376°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 91

2. LEASING: None identified

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Mickey H.S., Harney County, Oregon

Leasing has been the only development activity to occur at this site. Major leaseholders include Al Aquitane, Supron, Anadarko, and Getty. The State of Oregon plans to initiate drilling activities at this site in 1983. If the drilling operations prove successful, electric power generation is feasible by the early 1990's.

SITE: Mickey H.S., Harney County, Oregon

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 205 (401°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 160

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	106,438	(Combined 93,562)		200,000
Acreage Leased	29,598	0	0	29,598

Major Lease Holders - Al Aouitaine, Data Funds, Supron, California
Geothermal

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	12	6	3	3

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	23	21	21	0

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Neal H.S., Oregon

Leasing activity has been reasonably positive, but very little exploration has occurred. Major leaseholders at the site include Earth Power, Thermal Resources, and U.S. Geothermal. Development of this site is not anticipated for quite some time.

SITE: Neal H.S., Oregon

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 188 (370°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 36

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	47,362	(Combined	26,975)	74,157
Acres Leased	21,825	?	?	?

Major Lease Holders - Earth Power, Thermal Resources, U.S.
Geothermal

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	0	0	0	0

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	16	9	2	5

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Newberry Caldera, Deschutes County, Oregon

No development activity has taken place at this site. Several environmental groups have indicated that they would strongly oppose geothermal development. The State of Oregon has declared the site as being unsuitable for electric power development. Chances are extremely remote that this area will be developed.

SITE: NEWBERRY CALDERA, OR

SITE: Newberry Caldera, Deschutes County, Oregon

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 230 (446°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 740

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	609,000	(Combined	41,000)	650,000
Acreage Leased	?	?	?	?

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Trout Creek Area, Oregon

Relatively minor development activity has been noted at this site. Initial results of well testing activities have indicated both low temperature and flow rates. It does not appear that the site is a good prospect for development.

SITE: Trout Creek Area, Oregon

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): 6,560
Reservoir Area (sq. miles): ?
Temperature (°C): 154 (309°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 24

2. LEASING: None identified

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

SITE: Gamma H.S., Washington

The stie is located in an extremely remote area and is very near inaccessible. It is also designated as being part of a wilderness area. It is relatively certain that the site will never be developed.

SITE: GAMMA HOT SPRINGS, WA

SITE: Gamma H.S., Washington

1. RESERVOIR CHARACTERISTICS:

Depth to Reservoir Top (ft): ?
Reservoir Area (sq. miles): ?
Temperature (°C): 165 (329°F)
Total Dissolved Solids (ppm): ?
Electric Energy Potential (MWe 30 years): 27

2. LEASING:

	<u>Federal</u>	<u>State</u>	<u>Private</u>	<u>Total</u>
Acres Available	24,000	0	0	24,000
Acreage Leased	0	0	0	0

	<u>Tracts Offered</u>	<u>Tracts Bid</u>	<u>Tracts Term./Relinq.</u>	<u>Existing Leases (Tracts)</u>
Competitive Leasing	0	0	0	0

	<u>Applications Filed</u>	<u>Leases Issued</u>	<u>Rejected/ Withdrawn</u>	<u>Pending</u>
Non Competitive Leasing	20	0	10	10

3. WELL DRILLING: None identified

4. PERMITTING INFORMATION: None identified

5. POWER PLANTS: None operational or proposed

APPENDIX B

SCHEDULED LEASE SALES

SCHEDULED LEASE SALES

State	Area	#Tracts	Acreage	Date of Sale	Offered By
NM	Baca	2	3,750.79	8/26/81	BLM
NM	San Ysidro	2	1,112.72	8/26/81	BLM
NM	Socorro Peak	14	21,093.748	8/26/81	BLM
NM	Lightning Dock	3	5,058.37	8/26/81	BLM
VT	Juab, Washington, Iron, & Box Elder Counties	9	3,899.5	8/31/81	Utah Dept. of Natural Resources
CA	Coso	28	60,862.78	9/15/81	BLM
CA	East Mesa		11,679.48	9/29/81	BLM
CA	Geysers		4,807.82	9/29/81	BLM
NV	Brady Hazen	15	28,683.63	9/29/81	BLM
NV	Dixie Valley	9	17,225.98	9/29/81	BLM
NV	Elko Hot Springs	2	1,320.00	9/29/81	BLM
NV	Monte Neva	4	7,554.60	9/29/81	BLM
NV	Salt Wells Basin	8	19,226.88	9/29/81	BLM
NV	Wabuska	3	5,640.00	9/29/81	BLM
CA	Mendocino & Sonoma City	1	440.00	10/1/81	California State Lands Commission
CA	Lake and Mendocino Counties	1	240.00	10/1/81	California State Lands Commission
CA	Lake County	1	800.00	10/1/81	California State Lands Commission
CA	East Brawley			10/1/81	BLM
CA	Randsburg			10/1/81	BLM
AZ	Gillard Hot Springs			10/1/81	BLM
AZ	Clifton			10/1/81	BLM
CA	Mono-Long Valley			10/15/81	BLM

SCHEDULED LEASE SALES (CONT'D)

State	Area	# Tracts	Acreage	Date of Sale	Offered By
CA	Glass Mountain			11/19/81	BLM
CA	Becksworth Peak			12/10/81	BLM
CA	Lassen Hot Springs			12/10/81	BLM
WA	Indian Heaven			12/16/81	BLM
CA	Bodie			1/5/82	BLM
CA	Ford Dry Lakes			1/5/82	BLM
OR	Belknap-Foley Hot Springs			2/24/82	BLM
OR	Carey Hot Springs			2/24/82	BLM
OR	Newberry Caldera			6/17/82	BLM
OR	McCredie Hot Springs			10/14/82	BLM

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