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LOW-TEMPERATURE RESOURCE ASSESSMENT

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ABSTRACT

The U.S. Department of Energy - Geothermal Division (DOE/GD) recently sponsored the Low-Temperature Resource Assessment project to bring the inventory of the nation's low- and moderate-temperature geothermal resources up to date and to encourage development of the resoureces. A database of more than 9,278 thermal springs and wells that are in the temperature range of 20 to 150°C has been compiled for ten western states, an increase of 85% compared to previous assessments. The databases include location, descriptive data, physical parameters, water chemistry and references for sources of data. Computer generated maps are also available for each state. State Teams have identified more than 50 high-priority areas for near-term comprehensive resource studies and development. Geothermal energy cost evaluation software has been developed to quickly identify the cost of geothermally supplied heat to these areas in a similar fashion to that used for conventionally-fueled heat sources.

INTRODUCTION

Low- and moderate-temperature geothermal resources are widely distributed throughout the western and central United States. Numerous resources occur in the areas indicated in Figure 1, with individual reservoir areas one to ten square miles in extent. In the northern Great Plains, major aquifers with fluid temperatures exceeding 50°C extend in a continuous manner for thousands of square miles. Geothermal resources also occur at certain locations in the east.

The last major effort in assessing the national potential of low-temperature geothermal resources occurred in the early 1980s. Since that time, substantial resource information has been gained through drilling for hydrologic, environmental, petroleum and geothermal projects, but there has been no significant effort to compile information on low-temperature geothermal resources.

While there has been a substantial increase in direct-heat utilization during the last decade, the large resource base is greatly under-utilized. Since the thermal energy extracted from these resources must be used near the reservoir, collocation of the resource and the user is required. Development of a user facility at the site of the hydrothermal resource is often economically feasible. Direct-heat resources are typically used by small businesses, various types of local industry, communities, and individuals. These users generally need the technical expertise to delineate and develop geothermal resources from scratch.

To expand utilization of the direct-heat resource, a current inventory of these resources is needed by potential users, together with the information necessary to evaluate the reservoirs and the economics of potential uses. To stimulate the development of an industry, it is necessary to reduce risks of development and this can be done by providing resource data and by cost-sharing of demonstration projects.

COMPILATION OF DATA ON HYDROTHERMAL RESOURCES

State geothermal resource teams (State Teams) reviewed and updated their geothermal resource inventories which were completed as part of the USGS-DOE national assessment from 1977-1983 (Muffler, 1979 and Reed, 1983). Each State Team prepared a comprehensive digital database in table format and a resource map at a scale of 1:1,000,000. ESRI and OIT have provided technical guidance and coordination. ESRI completed fluid chemistry analyses for participating states. Databases are designed to be readily accessible and maintained on PCs . Computer sorting,. selection and comparison routines were employed to edit the new databases.

The compilations included resources in the temperature range of 20° to 150°C. Many of these resources have potential to supply energy to collocated

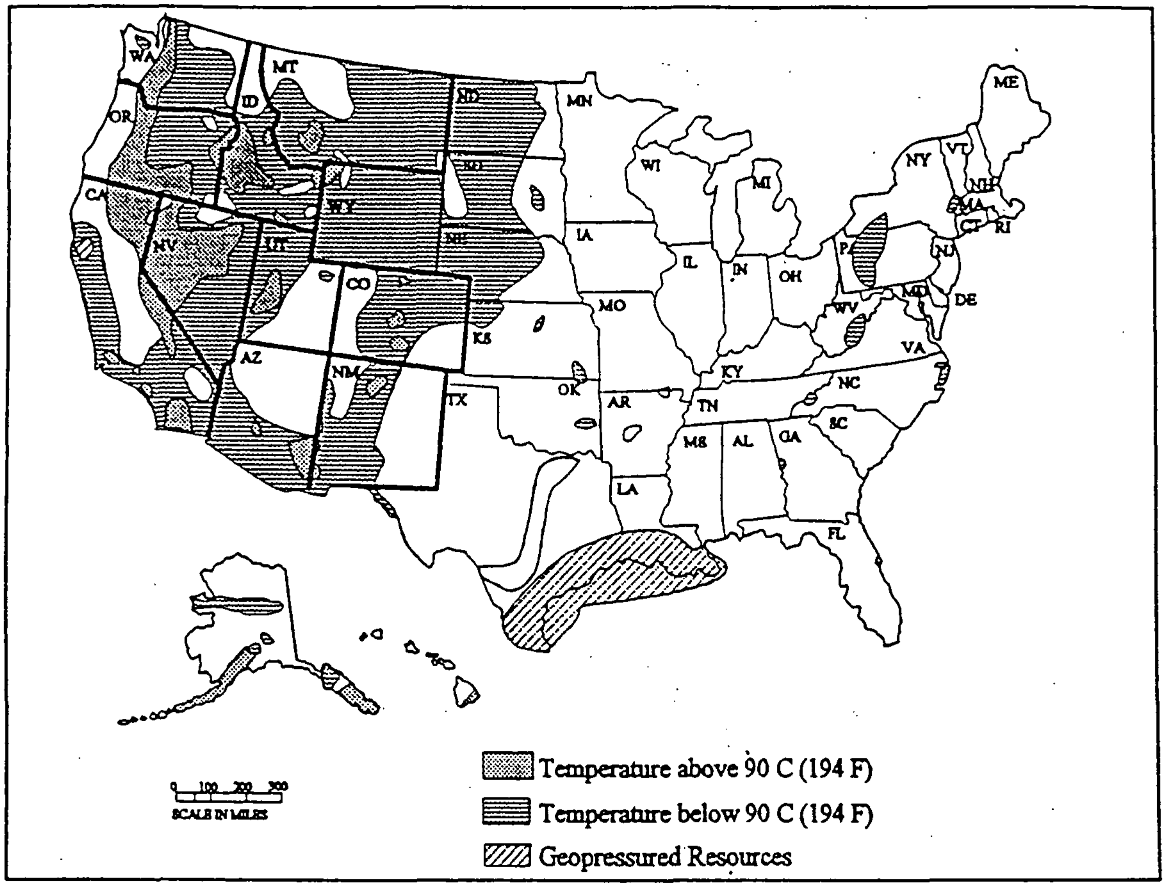

Figure 1. Geothermal Resource Areas of the United States with the ten states involved in the new resource assessment identified in bold outlines.

cities within approximately 8 km of a resource as well as greenhouses, aquaculture, mining, and other process applications.

The State Teams reviewed drilling records and other information to identify new resources, verified temperatures and flow rates of springs and wells which may have changed substantially since the previous statewide geothermal resource inventory. The databases were organized into tables linked by common data-fields, using the preliminary database from the Utah Geological Survey as a model for uniformity in presentation (Blackett, 1994). Information in the tables included: Table 1 contains location data, desciptive data, and physical parameters of the thermal springs and wells; Table 2 contains data that relate to water chemistry, and Table 3 repeats some data that are in Table 1, but it primarily lists the source references from which the data was obtained.

Simultaneously, demographic and other data were collected and interpreted to evaluate potential heat loads, fossil-fuel displacement, utility electrical-demand reduction and load-leveling opportunities, and environmental benefits for potential geothermal direct-heat applications.

RESULTS OF RESOURCE EVALUATION

State geothermal resource teams (State Teams) initiated their resource evaluation and database compilation efforts in late 1992 and early 1993, and have now updated their resource inventories. Table 1 summarizes the catalog of more than 9,278 thermal wells and springs for these 10 western states, an increase of 85% compared to the previous assessment in 1980 to 1983. More than 900 low- to moderate-temperature resource areas are indicated, and perhaps a greater number of isolated (singular) thermal wells or springs. Direct-heat use of geothermal fluids is

Table 1. State Geothermal Database Summary: 1992-94 Low-Temperature Assessment.

	State	AZ	CA	CO	ID	MT	NV	NM	OR	UT	WA
	PGA	1982	1980	1980	1980	1981	1983	1980	1982	1980	1981
Thermal Well/ Springs	1993	1,003	979	157	912	267	455	265	2,193	964	975
	PGA	501	635	125	899	68	796	312	998	315	368
Moderate Temp. Wells/Springs (100°C < T < 150°C)	1993	0	32	0	20	0	16	10	88	3	1
	PGA	0	48	0	0	0	35	3	79	3	1
Low Temp. Wells/Springs (20°C < T < 100°C)	1993	1,003	957	157	1,915	97	433	255	2,047	710	970
	PGA	501	587	125	899	58	761	309	925	312	367
Low Temp. Resource Areas (20°C < Tes < 150°C)	1993	35	58	93	28	16	300	30	200	161	17
	PGA	29	56	56	28	15	300	24	151	64	10
Direct-Heat Utilization Sites (Commercial, district, resorts)	1993	2	72	28	29	15	21	7	29	16	4
	PGA	0	54	24	20	2	8	0	23	9	0
Greenhouses, Aquaculture, Industrial Processes	1993	5	17	4	17	4	8	6	7	6	0
Areas, High Priority Resource Study	1993	4	7	6	8	5	5	12	5	7	6

Comments: PGA - Previous Geothermal Assessment. Tres = Estimated reservoir temperature.
The minimum low-temperature criteria is typically 20°C, but varies with climate.

documented at more than 350 sites, including commercial and municipal buildings, rapidly expanding greenhouse and aquaculture industries, and major space-heating districts in California, Oregon, Nevada, Idaho, and Colorado. More than 50 high-priority resource study areas have been identified, along with high potential for near-term direct-heat utilization at 150 new sites. Previous estimates indicate that 254 cities in 10 western state could potentially displace 18,000 GWh per year (17 million BOE) with geothermal district heating (Allen, 1980). The number of commercial and residential direct-heat users and the total energy use have increased dramatically in one decade. Table 1 indicates the tremendous potential for expanded utilization of these resources. The new digital database reports are, in most cases, available as Open-File reports from each State Team listed in the References.

COLLOCATION OF RESOURCES

An important part of the assessment was to complete a collocation study of geothermal resources and communities in the western states in order to identify and encourage those communities to develop their geothermal resources. For example in California, 56 communities were identified that are located within 8 km of a known geothermal resource with a temperature of at least 50°C (Youngs, 1994). The communities are shown on the state map on Figure 3.

Historically, most of the communities that were identified have experienced some development of their geothermal resources. However, depending on the characteristics of the resource, the potential exists for increased goethermal development for applications such as space and district heating, resort/spa facilities, aquaculture, industrial and greenhouse operations, and possible electrical generation in some areas.

GEOTHERMAL ENERGY COST EVALUATION

Each State Team has selected (partially based on population data and the need for more comprehensive resource studies) high-priority areas for proposed near-term resource studies and development. It is important to characterize these energy sources in terms of cost, both capital and unit energy cost. Geothermal energy costs vary with depth and character of the resource, number of production and injection wells, and many other parameters. Software has been devloped at the Geo-Heat Center to quickly identify the cost of geothermally supplied heat in a similar fashion to that used for conventionally fueled heat sources (Rafferty, 1995).

Using resource, financing and operating inputs, the spreadsheet calculates the capital cost for production well(s), well pump(s), wellhead equipment, injection well(s), and connecting pipelines. These capital costs are used along with the quantity of annual energy to be supplied and financing information to produce a unit cost of energy. Unit costs for operation (maintenance and electricity) are added to arrive at a total unit cost in $ per million Btu for geothermal heat. To put this value into perspective, similar costs for an equivalent-sized boiler plant are also calculated. These values can then be compared to determine the relative economic merit of geothermal for any specific set of circumstances. This information is particularly useful at the conceptual stage of a project when decisions as to fuel source are typically made by the developers.

A general example of the use of the spreadsheet is illustrated in Figure 2. Consider a local economic development agency in an area of known geothermal resources. The economic development agency may wish to determine the relative economic merit of geothermal use for new industrial developments as a function of required well depth. Output from the spreadsheet can be used to develop the curve illustrated. This graph assumed a 6 MW_t load at two different load factors: 20% representing greenhouse or multi-building district heating, and 30% representing an industrial process load. The basis for the cost competiveness graph is:

- Electric costs @ 0.07 $/kWh and 0.05 $/kW,
- One production well/one injection well (where applicable),
- 20 year financing @ 8%;
- 60% hard drilling and 40% soft drilling,
- Open-hole completion on production well,
- Lineshaft production well pumps,
- Full depth casing on injection wells,
- Natural gas rate @ 0.43/therm and 75% efficiency, and
- Based on geothermal system supplying 100% of peak.

As illustrated in Figure 2, even for this relatively small load, conditions are favorable (simple payback less than 5 years) for geothermal for all applications up to a well depth of 762 m without injection and for higher load factor (30%) with injection. For lower load factor (20%) applications, a well depth of up to 610 m with injection provides simple paybacks of less than 5 years.

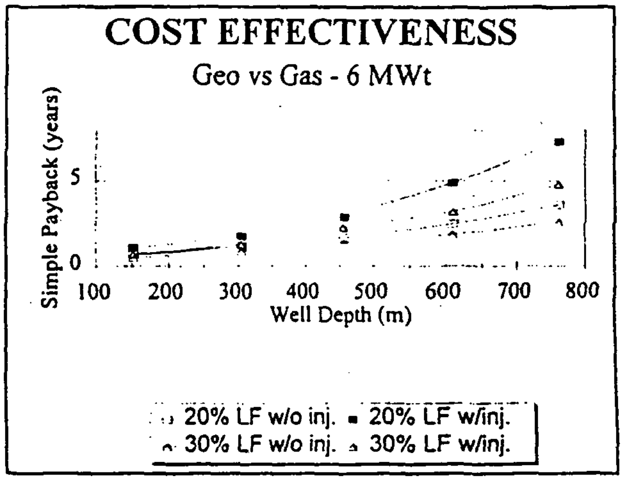

Figure 2. Cost effectiveness of geothermal versus natural gas - 6 MW_t system.

CONCLUSIONS

Low- and moderate-temperature geothermal resources are widely distributed throughout the western and central United States. Since the last major effort in assessing the national potential of these resources in the early 1980s, there has been a substantial increase in direct-heat utiliztion. However, the large resource base is greatly under-utilized. To expand utilization of the direct-heat resource base, a current inventory of these resource has been developed.

State geothermal resource teams (State Teams) evaluations and compilations have resulted in the catalogging of more than 9,278 thermal wells and springs for ten western states, an increase of 85% over the previous geothermal assessment in 1980 to 1983. More than

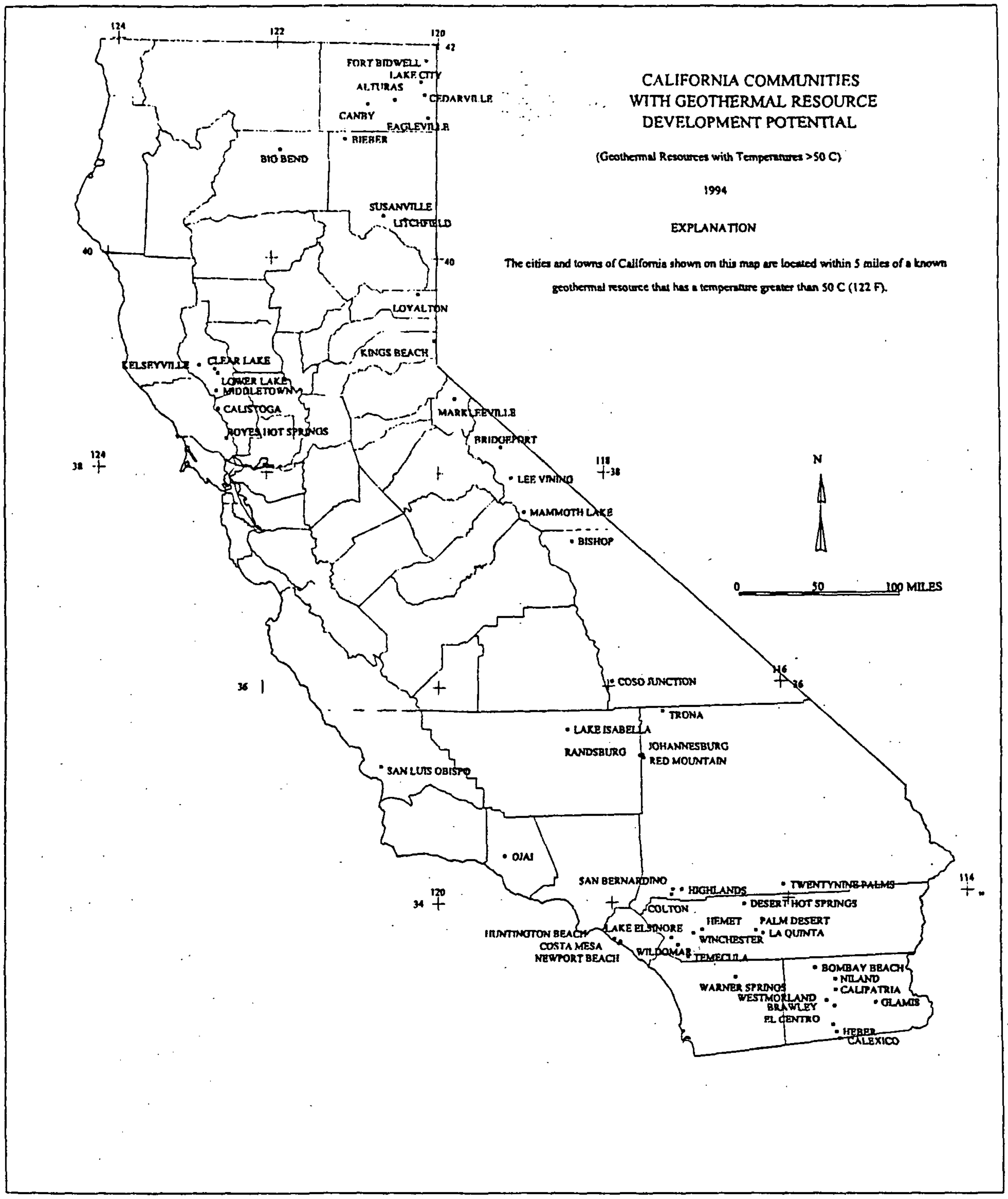

Figure 3. California communities with geothermal resource development potential.

than 50 high-priority resource study areas have been identified, along with high potential for near-term direct-heat utilization at 150 new sites.

Although the compilation of recsource data by State Teams indicates the tremendous potential for expanded utilization of these resources, many high-priority areas need comprehensive resource and preliminary engineering studies. More specifically, for over 50 sites these include:

- Geophysical exploration (10 sites)
- Confirmation drilling (12 sites)
- Hydrologic testing (11 sites)
- Comprehensive assessment (8 sites)
- District heating feasibility (12 sites)
- Industrial heating feasibility (7 sites)

These tasks are expected to pay off in further discoveries of resources and in better methods to evaluate reservoir production and ultimate development capacity at an earlier stage in the development cycle than is now possible.

ACKNOWLEDGEMENT

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