A NEW U.S. LOW-TEMPERATURE RESOURCE ASSESSMENT PROGRAM

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ABSTRACT

In Fiscal Year 1991, the United States Congress appropriated money for the Department of Energy to begin a new program in the evaluation and use of low- and moderate-temperature (20° to 150°C) geothermal resources. The objective of this program is to promote accelerated development of these resources to offset fossil-fuel use and help improve the environment.

The assessment program has resulted in digital databases reporting on 8,170 thermal wells and springs for 10 western states, an increase of 40% compared to the previous assessment in 1980. More than 900 resource areas were indicated and 45 of these have been identified as high-riority study areas for 150 near-term direct-heat utilization sits.

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 1 to 10 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 (Reed, 1983). 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- and moderate-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 cannot afford to hire the technical expertise required 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.

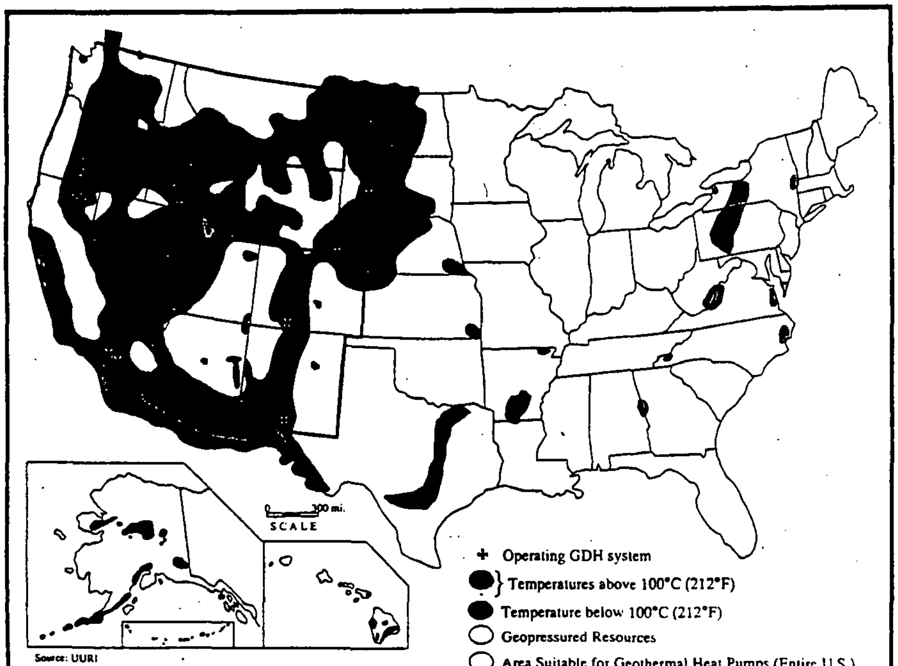

Figure 1. Geothermal Resource Areas of the United States.

LOW-TEMPERATURE PROGRAM

The program is a cooperative effort among a number of academic and state institutions working with potential direct-heat developers. The three principal institutions are the Geo-Heat Center at the Oregon Institute of Technology (OIT), the Idaho Water Resources Research Institute at the University of Idaho (IWRRI), and the Earth Science Laboratory of the University of Utah Research Institute (UURI). State geothermal resource teams (State Teams) compiling data for ten states in the west are also participating. The tasks for this project are discussed below.

Compilation of Data on Hydrothermal Resources

State Teams reviewed and updated their geothermal resource inventories which were completed as part of the USGS-DOE national assessment from 1977-1983 (Reed, 1983). Each state prepared a comprehensive digital database in table format and a resource map at a scale of 1:1,000,000. UURI and OIT have provided technical guidance and coordination, and UURI completed fluid chemistry analyses for participating states. Table 1 identifies the state agencies and principal investigators involved with the project.

The compilations included resources in the temperature range of 20° to 150°C. Many of these resources have the potential to supply energy to collocated cities within approximately 8 km of a resource as well as greenhouses, aquaculture, mining, and other process applications.

The State Teams, under subcontract to OIT and with guidance from UURI, reviewed drilling records and other information to identify new resources and verify 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, 1993). Information contained in the tables includes: location (ID number, source name, county code, latitude and longitude); description (ID number, source name, type of source, temperature (°C), flow rate (L/min), depth of wells (m), current resource use, and references to relevant studies of geology, geophysics, geochemistry, hydrology completed for the site), and geochemistry (ID number, source name, pH, TDS, major cations, major anions, cation-anion balance, chemical species that may cause scale and corrosion products, and light stable isotopes). 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.

Preliminary Results - Resource Evaluation

State Teams for 10 western states initiated their resource evaluation and database compilation efforts in late 1992 and early 1993, and have now updated their resource inventories. Table 2 summarizes the catalog of 8,170 thermal wells and springs for these 10 western states; an increase of 40% compared to the previous assessment in 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 documented at more than 250 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 40 high-priority resource study areas have been identified, together with high potential for near-term direct-heat utilization at 150 new sites. Preliminary estimates indicate that 254 cities in 10 western state could potentially displace 18,000 GWh per year (17 million BOE) with geothermal district heating. The number of commercial and residential direct-heat users and the total energy use have increased dramatically in one decade. Some highlights from the participating follow.

Arizona. The 1992-1993 assessment shows a 100% increase in the number of thermal wells and springs. These wells and springs are delined as 35 low-temperature resource areas and an additional 205 singular thermal wells and springs. Arizona leads the nation in the use of geothermal fluids for aquaculture (Witcher, 1994).

California. The California Division of Mines and Geology reports 979 thermal wells and springs. Some 58 low-temperature resource areas have been identified with an additional 194 "singular" thermal occurrences. The 72 commercial direct-heat users include six district-heating systems, 48 resorts/spas, and 17 greenhouse, aquaculture or industrial concerns (Youngs, 1994).

Colorado. The 1992-1993 assessment reports that there are 93 goethermal areas (usually less than 8 km^2 in size) in Colorado, up from the 56 reported in 1978; there are 157 geothermal sites compared to the 125 reported in 1978. Six goethermal areas are recommended for further investigation: Trimble Hot Springs,

Table 1. State Resource Assessment Teams

State	Agency	Principal Investigator
California	Division of Mines and Geology	Leslie Youngs
Colorado	Colorado Geological Survey	James Cappa
Idaho	Idaho Water Resources Research Institute	Leland Mink William Dansart
Montana	Bureau of Mines and Geology	Wayne Van Voast John Metesh
New Mexico and Arizona	New Mexico State University- Southwest Technology Development Institute	James Witcher and Rudi Schoenmackers
Nevada	Bureau of Mines and Geology	Larry Garside
Oregon	Dept. of Geology and Mineral Industries	George Priest Gerald Black
Utah	Utah Geological Survey	Robert Blackett
Washington	Division of Geology and Earth Science	Eric Schuster

Table 2. **State Geothermal Database Summary: 1992-93 Low-Temperature Program.**

	State PGA	AZ 1982	CA 1980	CO 1980	ID 1980	MT 1981	NV 1983	NM 1980	OR 1982	UT 1980	WA 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, Potential Near-Term Direct Heat Utilization	**1993**	**4**	**2**	**4**	**51**	**2**	**2**	**4**	**25**	**7**	**24**
Areas, High Priority Resource Study	**1993**	**3**	**4**	**6**	**5**	**4**	**4**	**4**	**5**	**4**	**6**

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

Orvis Hot Springs, an area southeast of Pagosa Springs, the eastern San Luis Valley, Rico and Dunton area, and Cottonwood Hot Springs (Cappa, 1994).

Idaho. The Idaho Water Resources Research Institute lists 912 thermal wells and springs, more than the 899 reported in the 1980 inventory, but only half the total number of well and spring entries reviewed. Although district heating is well established at Twin Falls and Boise, there is high potential at about 50 sites for new direct-heat utilization, as well as some potential for electrical power development.

Montana. The Montana Bureau of Mines and Geology database contains information on location, flow, water chemistry, and estimated reservoir temperatures for 267 geothermal wells and springs. Low- and moderate-temperature wells and springs can be found in nearly all areas of Montana, but most are in the western third of the state. Five areas of Montana were chosen for future investigations of geothermal development based on the potential of the resource and its proximity to population centers. The areas identified are those near Bozeman, Ennis, Butte, Boulder, and Camas Prairie (Metesh, 1994).

Nevada. The Nevada Bureau of Mines and Geology includes 453 entries in a database which represents more than 3,000 wells and springs. More than 300 separate resource areas may be present in Nevada. Direct heat is utilized at 21 areas, including the Moana and Elko district-heating systems and the Duckwater (Big Warm) Springs aquaculture facility (Garside, 1994).

New Mexico. The Southwest Technology Development Institute reports 265 thermal wells and springs. Thirty low-temperature resource areas and perhaps 158 isolated thermal occurrences have been identified. New Mexico currently leads the nation with the largest acreage of geothermally-heated greenhouses on line, and expansion continues (Witcher, 1994).

Oregon. The new Oregon Department of Geology and Mineral Industries study identified 2,193 geothermal sites. More than 200 thermal areas have been identified. Geothermal fluids are used for heating over 625 buildings by businesses, organizations, and home-owners. Several greenhouses, aquaculture sites and industrial processes also use geothermal energy. Five high-priority resources study areas have been identified by DOGAMI and perhaps 25 businesses or organizations could utilize geothermal heating in the near term (Black, 1994).

Utah. The Utah Geological Survey compiled a database consisting of over 964 records on thermal wells and springs with temperatures of 20°C or greater; 300% of the previous geothermal assessment. Areas for future exploration and development interest include: southern Sevier Desert, where evidence suggests the possiblity of an undiscovered moderate to high-temperature system, and the eastern Escalante Desert, where high near-surface temperatures indicate a concealed geothermal system. Other direct-use opportunities for low-temperature geothermal resources are apparent within populated areas along the Wasatch Front (Blackett, 1993).

Washington. A detailed study by the Washington State Department of Natural Resources team has identified 971 thermal wells/ springs, 264% of the 1981 inventory, and several newly recognized low-temperature resources areas. Geothermal resource utilization is currently very low, but six counties are regarded as priority study areas, and as many as 49 potential users (commercial, private, or municipal) are collocated with promising resources (Schuster, 1994).

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 Teams evaluations and compilations have resulted in the catalogging of 8,170 thermal wells and springs for 10 western states, an increase of 40% over the previous geothermal assessment in 1983. More than 40 high-priority resource study areas have been identified, together with high potential for near-term direct-heat utilization at 150 new sites.

In the future we hope to continue R&D on more cost effective methods for locating low-and moderate-temperature geothermal resources and on siting successful test and production wells. Part of this work will encompass development of improved well-testing methods and better hydrologic models of these hydrothermal resources. 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.

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