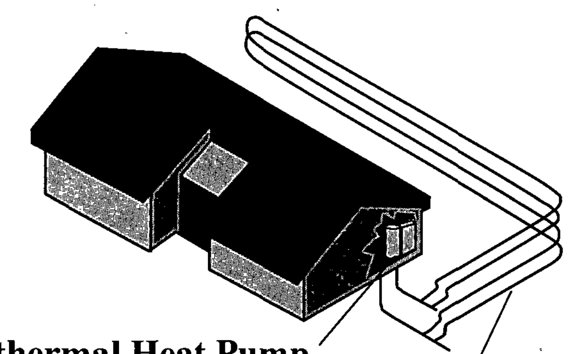
focused on identifying those portions of the country which have particular favorability for installation of earth-coupled and groundwater heat pumps. IWRRI has shown that well over one-half of the country, particularly the central and the southeast, possess the hydrogeologic characteristics necessary to make the ground water heat pump a very viable option. UURI has completed GHP fact sheets documenting residential and commercial GHP system performance, economic analysis and benefits, and distributed these widely.

The next step in this program will be to begin work with utilities to provide them with updated information on GHPs and to induce them to adopt this technology to help achieve their DSM programs in a lasting way.



Geothermal Heat Pump

Closed Horizontal Ground Loop

For additional information:

State Resource Assessment Teams

CALIFORNIA
Leslie Youngs
California Division of Mines and Geology
Sacramento, CA 95814
Tel. (916) 322-8078

COLORADO
James Cappa
Colorado Geological Survey
Denver, CO 80203
Tel. (303) 866-2611

IDAHO
Roy Mink
Idaho Water Resources Research Institute
University of Idaho
Moscow, ID 83843
Tel. (208) 885-6429

MONTANA
Wayne Van Voast and/or John Metesh
Montana Bureau of Mines and Geology
Montana College of Science and Technology
Butte, MT 59701
Tel. (406) 496-4169

NEVADA
Larry Garside
Nevada Bureau of Mines and Geology
University of Nevada, Reno
Reno, NV 89557-0088
Tel. (702) 784-6691

NEW MEXICO & ARIZONA
James Witcher and/or Rudi Schoenmackers
SW Technology Development Inst..
New Mexico State University
Las Cruces, NM 88003
Tel. (505) 646-3949

OREGON
George Priest and/or Gerald Black
Oregon Dept of Geology and Mineral Ind.
Portland, OR 97232
Tel. (503) 731-4100

UTAH
Robert Blackett
Utah Geological Survey
Salt Lake City, UT 84109-1491
Tel. (801) 467-7970

WASHINGTON
Eric Schuster
Washington Division of Natural Resources
Olympia, WA 98504-7007
Tel. (206) 902-1451

Program Guidance, Technical Assistance, and Outreach

OREGON INSTITUTE OF TECHNOLOGY
Paul Lienau and/or Gene Culver
Oregon Inst. of Technology-Geo-Heat Center
Klamath Falls, OR 97601
Tel. (503) 885-1750

IDAHO WATER RESOURCES RESEARCH INSTITUTE
Roy Mink
Idaho Water Resources Research Institute
University of Idaho
Moscow, ID 83843
Tel. (208) 885-6429

UNIVERSITY OF UTAH RESEARCH INSTITUTE
Mike Wright and/or Howard Ross
University of Utah Research Institute
Salt Lake City, UT 84108-1295
Tel. (801) 584-4422

IDAHO NATIONAL ENGINEERING LABORATORY
Joel Renner
EG&G Idaho, Inc.
Idaho Falls, ID 83415
Tel. (208) 526-9824

DEPARTMENT OF ENERGY - GEOTHERMAL DIVISION
Marshall Reed
U.S. Dept. of Energy/Geothermal Division
Washington, DC 20585
Tel. (202) 586-8076

DEPARTMENT OF ENERGY - GEOTHERMAL DIVISION
Lew Pratsch
U.S. Dept of Energy/Geothermal Division
Washington, DC 20585
Tel. (202) 586-1512

LOW-TEMPERATURE GEOTHERMAL RESOURCE ASSESSMENT AND GEOTHERMAL HEAT PUMP PROGRAM

1992 - 1993

This important program was funded as a special appropriation to the Department of Energy - Geothermal Division budget by Congress in 1991. The objectives were (1) to update the inventory of geothermal resources useful for direct-heat applications (such as greenhouse heating and district heating), and (2) to develop data which would accelerate use of geothermal heat pumps (GHPs) in the U.S. This document provides a summary of accomplishments to date and discusses funding needs to complete the program.

LOW-TEMPERATURE GEOTHERMAL RESOURCES

Barriers to Widespread Use

Several barriers inhibit rapid development of geothermal resources for direct-heat application. The most troublesome of these barriers are:

- Limited knowledge of the resource.
- Limited infrastructure of experienced consultants and A&E firms.
- Cost of development.

Accomplishments to Date

To date, the resource assessment program has been concentrated in 10 states having high potential: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah and Washington. Resource inventories of ten years ago had identified some 5,600 thermal wells and springs in these 10 states. The new database now includes 11,300 entries, giving an indication of the enormous potential for development of clean, domestic geothermal-heat resources.

Funding Needs

This program needs to be continued and strengthened. Funding would be used to stimulate development of low- and moderate-temperature resources through cost-sharing of demonstration projects to spur infrastructure development and bring costs down.

FUNDING NEEDED ($ millions)

FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000
5.5	5.0	5.0	4.5	3.0	2.0

Anticipated Results

At the conclusion of this program, we anticipate being able to increase the amount of direct-heat geothermal power on line from 670 thermal megawatts to 3,700 thermal megawatts. With displacement of fossil fuels, this would save the emissions of about 1,550,000 tons of carbon dioxide, 30 tons of sulfur dioxide and 1,400 tons of nitrogen oxides per year.*

GEOTHERMAL HEAT PUMPS

Barriers to Widespread Use

Several barriers inhibit rapid introduction of geothermal heat pumps as an energy-saving measure. The most troublesome of these barriers are:

- Limited utility interest in demand-side management (DSM).
- Lack of promotion of geothermal heat pumps.
- Lack of an installation infrastructure in many parts of the country.

Accomplishments to Date

We have developed a map of areas in the United States most conducive to installation of GHPs. We have also developed case-study brochures for promotion of GHPs. Availability of this information will encourage utilities and their customers to consider the GHP option.

Funding Needs

This program needs to be continued and strengthened. Funding would be used for promotion of GHPs with the utilities and their customers through education and limited incentives. This would help build the infrastructure needed for GHP installation to accelerate on its own at the conclusion of this program.

FUNDING NEEDED ($ millions)

FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000
5.0	4. 5	4.5	4.0	3.5	2.0

Anticipated Results

At the conclusion of this program, approximately 1,500,000 geothermal heat pump systems would be installed in homes, schools and other buildings in the United States. Savings over today's level of generating capacity for heating and air conditioning would be at least 5,000 megawatts. With displacement of fossil fuels this would save the emissions of about 35,000,000 tons of carbon dioxide, 330,000 tons of sulfur dioxide and 130,000 tons of nitrogen oxides per year.*

**Emissions reductions are dependent on the fuel mix replaced and other factors. See EPA 430-R-93-004 "Space Conditioning: The Next Frontier" by M. L'Ecuyer, C. Zoi, and J.S. Hoffman, April 1993.*

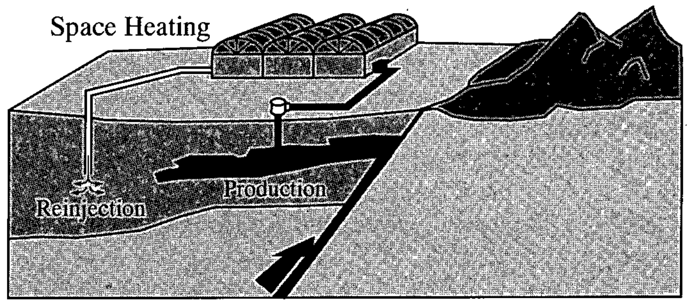
GEOTHERMAL ENERGY

Geothermal energy is renewable heat energy from deep in the earth. Heated groundwater forms hydrothermal resources - naturally occurring hot water and steam. Use of geothermal energy has environmental and reliability advantages over conventional energy sources. Geothermal energy contributes both to energy supply, with electrical power generation and direct-heat uses, and to reduced energy demand, with savings in electricity and natural gas through use of geothermal heat pumps to heat and cool buildings.

Use of hydrothermal energy is economic today at some high-grade sites. A modest industry generates electrical power and supplies heat for direct uses. Only a small fraction of our geothermal reserves are in use today. Much more could be brought on line in the short term with appropriate research, development and incentives.

Hydrothermal resources are tapped by existing well-drilling and energy-conversion technology to generate electricity or to produce hot water for direct use. For direct-heat application, water at temperatures ranging from about 80°F to more than

300°F is brought from the underground reservoirs to the surface through production wells. The geothermal water is usually fed to a heat exchanger for extraction of the heat before being injected back into the earth. Heated domestic water from the output side of the heat exchanger is used for commercial and home heating, greenhouse heating, vegetable drying, aquaculture and a wide variety of other energy needs.



RESOURCE BASE

Low- and moderate-temperature geothermal resources are widely distributed throughout the western and central United States. Numerous resources occur in the areas indicated on the map, with individual reservoir areas one to ten square miles in extent. In the northern Great Plains, major aquifers with fluid temperatures exceeding 50°C (122°F) extend in a continuous manner for thousands of square miles. Geothermal resources also occur at certain locations in the East.

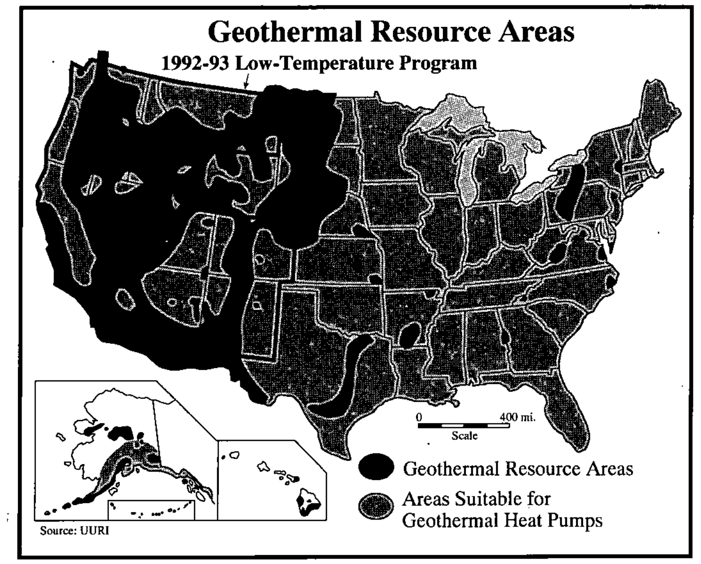
The last major effort in assessing the national potential of low-temperature geothermal resources occurred in the early 1980s. Since that time, substantial resource information has been gained through drilling for hydrologic, environmental, petroleum and geothermal projects, but there has been no significant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

1992-1993 LOW-TEMPERATURE PROGRAM

In 1991, Congress appropriated money for the Department of Energy to begin a new program for the evaluation and use of low- and moderate-temperature geothermal resources. The program is addressing two major national goals: 1) reduced



emission of greenhouse gases, acid rain-producing gases, and particulate matter to the atmosphere; and 2) reduced dependence on imported petroleum. The program has several components, including: (1) compilation of all available information on resource location and characteristics, with emphasis on resources located within 8 km (5 mi) of population centers; (2) development and testing of techniques to discover and evaluate low- and moderate-temperature geothermal resources; and (3) technical assistance to potential developers of these resources. Program participants include state government or university teams in ten western states. Program coordination is furnished by the Geo-Heat Center at the Oregon Institute of Technology (OIT-GHC), the University of Utah Research Institute (UURI), and the Idaho Water Resources Research Institute (IWRRI).

PRELIMINARY RESULTS - 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 11,000 thermal wells and springs for these 10 western states, more than twice the number on 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, along with high potential for near-term direct-heat utilization at 150 new sites. Preliminary estimates indicate that 254 cities in 10 western states could potentially displace 64 trillion Btu 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. Table 1 indicates the tremendous potential for expanded utilization of these resources, and is a compelling argument for continued funding of this productive program. Each state team is producing a new geothermal resource map showing thermal wells and springs for their state. The Geo-Heat Center (OIT) and UURI are working with state teams to evaluate the collocation of resources with communities

Table 1. 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 Wells and Springs	**1993**	**543**	**979+**	**157**	**1,935**	**346**	**3,300**	**247**	**2,135**	**713**	**971**
	PGA	501	635	125	899	68	1,376	312	998	315	368
Moderate Temp. Wells (100°C<T< 150°C)	**1993**	**0**	**73**	**0**	**20**	**0**	**50**	**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**	**543**	**906**	**157**	**1,915**	**97**	**1,000**	**237**	**2,047**	**710**	**970**
	PGA	501	587	125	899	58	700	309	925	312	367
Low Temp. Resource Areas (20°C<Tres<150°C)	**1993**	**29**	**58**	**93**	**28**	**16**	**300**	**29**	**275**	**161**	**17**
	PGA	29	56	56	28	15	300	24	151	64	10
Direct-Heat Utilization Sites (Commercial, district, resorts)	**1993**	**3**	**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**	**49+**
Areas, High Priority Resource Study	**1993**	**3**	**4**	**6**	**5**	**4**	**4**	**4**	**5**	**4**	**3**

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

and potential users, and to establish priorities for more detailed resource studies. Some highlights from selected states are:

California. The California Division of Mines and Geology reports more than 979 thermal wells and springs. Some 58 low-temperature resource areas have been identified with an additional 194 "singular" thermal occurrences. The 71 commercial direct-heat users include six district-heating systems, 48 resorts/spas, and 13 greenhouse, aquaculture or industrial concerns.

Idaho. The Idaho Water Resources Research Institute (IWRRI) lists 1,935 thermal wells and springs, more than twice the 899 reported in the 1980 inventory. 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.

Nevada. The Nevada Bureau of Mines and Geology (NBM&G) includes over 3,000 entries in a preliminary database. More than 300 separate resource areas may be present in Nevada. Direct heat is utilized at 20 establishments, including the Moana and Elko district-heating systems.

New Mexico. The Southwest Technology Development Institute (SWDI) reports 247 thermal wells and springs. Twenty-nine low-temperature resource areas and perhaps 151 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.

Oregon. The new Oregon Department of Geology and Mineral Industries (DOGAMI) database includes 2,135 entries. More than 200 thermal areas have been identified. Geothermal fluids are used for heating over 625 buildings by businesses, organizations, and homeowners. Several greenhouses, aquaculture sites and industrial processes also use geothermal energy. Five high-priority resource study areas have been identified by DOGAMI and perhaps 25 businesses or organizations could utilize geothermal heating in the near term.

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

1992-1993 GEOTHERMAL HEAT PUMP PROGRAM

Geothermal heat pumps (GHPs) use normal-temperature earth or groundwater for heating during the winter, cooling during the summer, and supplying hot water year around. Because of their high efficiency, GHPs save significant amounts of electricity and natural gas compared to other heating and cooling systems. They are a preferred technology of the EPA.

DOE has been working to increase the use of GHPs throughout the country. OIT has been collecting and interpreting engineering data on the performance of residential and commercial installations of geothermal heat pumps from throughout the nation. In addition, it has been investigating utility demand-side management (DSM) programs to determine: (1) the most effective and successful utility marketing and incentive programs to expand GHP markets; (2) barriers to market entry; (3) the benefits to utilities from reduced peak demand and higher annual load factors; (4) the number of GHP units installed in utility areas; and (5) suitability of GHPs for northern climates. IWRRI has