GEOTHERMAL DIRECT USE

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**Paul J. Lienau and John W. Lund
Geo-Heat Center
Oregon Institute of Technology**

Introduction

Enormous potential exists in the United States for geothermal direct-use and ground-source heat pumps to make a significant contribution to our national energy needs, while offsetting the use of fossil fuels. Implementation of geothermal projects will reduce gaseous emissions and acid rain from the combustion of fossil fuels that impact our environment. Geothermal direct use has practically zero emission of greenhouse-type gases and essentially no thermal pollution.

The low-to-moderate temperature (<190 to 300°F) geothermal resources base (38,900 Quads) is much more plentiful and widespread than the high-temperature (>300°F) resource base (4,800 Quads). A recent report prepared for DOE by Meridian Corporation (Meridian, 1989) compares the magnitudes of the energy resource base in the U.S. as shown in Table 1. There is nearly 20 times more geothermal energy than the energy we could derive from burning all the coal in the U.S., and 300 times the energy available in oil and gas. Geothermal energy is a domestic resource that contributes to our national energy security and decreases our trade deficit, while saving petroleum for higher priority uses.

Table 1

U.S. ENERGY RESOURCES (BBOE)*

Energy Source	Resource Base	Accessible Resources	Energy Reserves
Coal	15,079	6,577	908.0
Biomass and Solar	178,438	101,153	—
Biomass	—	—	57.7
Geothermal	256,992	3,897	42.5
Natural Gas	294	153	39.9
Petroleum	477	190	26.9
Hydro	170	27	8.0
Uranium	203	126	7.3
Solar	—	—	3.0
Wind	176,370	960	<1
Shale Oil	27,518	2,018	<1
Peat	244	61	<1

* Billion Barrels of Oil Equivalent

Lack of an adequate resource database and risk of failure in exploration and drilling have prevented geothermal direct use from achieving its full potential. Development of these resources can lead to space conditioning of buildings, greenhouse heating, aquaculture and other industrial applications. The current status is that an estimated annual energy contribution of over 19,000 billion Btu per year (0.02 Quads or 5.5 million BOE) can be attributed to the direct use industry. This represents only a small fraction of the potential (Lund, et al., 1990). Figure 1 illustrates the relative annual energy use for each direct heat application.

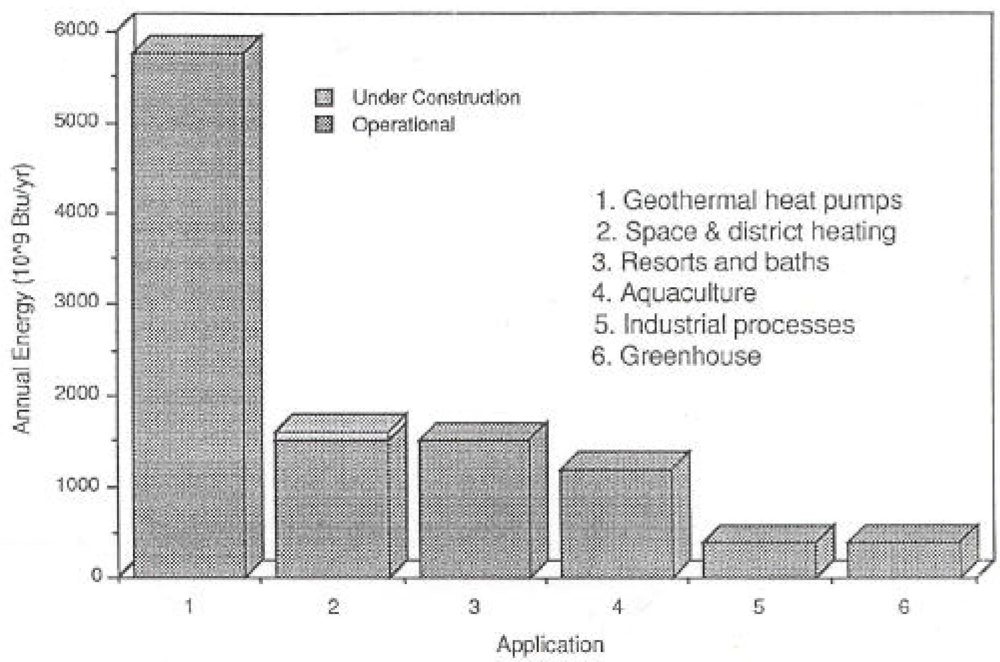

Figure 1. Relative annual energy use for the six major direct use applications. (Thermal enhanced oil recovery is not included estimated at 8,200 x 10^9Btu/yr.)

Low-to-moderate temperature resources in the United States are widespread (Figure 2) and can provide a source for many direct heat applications. In contrast to other renewable resources, geothermal energy is not hindered by a cyclical output as in the case of wind and solar. It is a base load (constant output) resource, the application of which does not require sophisticated storage strategies. Geothermal energy in the low-temperature range can have a significant impact on U.S. energy consumption, especially with regard to space heating. Space heating in the 120 to 170°F range is by far the largest single U.S. energy use, representing 45 percent of all energy use below 500°F. Matching geothermal resources to meet these space heating requirements would result in much better use of U.S. energy reserves and reduce emissions from fossil fuel.

Geothermal Heat Pumps

The largest potential use of geothermal energy is for geothermal heat pumps (GHP). Geothermal heat pumps have national appeal because stable temperatures in the range of 40 to 70°F occur nationwide at depths below 30 ft (Braud, 1992). The GHP is the highest efficiency heating and cooling system available, provides much lower energy costs for the consumer and greatly reduces electric peak demand for the utility. GHPs represent a demand-side management option for utilities to avoid building new power plants. A typical home using a GHP will shave about 5 kW off winter peak heating demand and about 2.5 kW from summer demand. Thus, 200,000 homes using GHPs would avoid construction a new 1,000 MW power plant. Although the incremental cost of the ground-coupled closed loop adds about $2,000 to the cost of a residential heating system, paybacks occur in 3 to 5 years from money saved on utility bills.

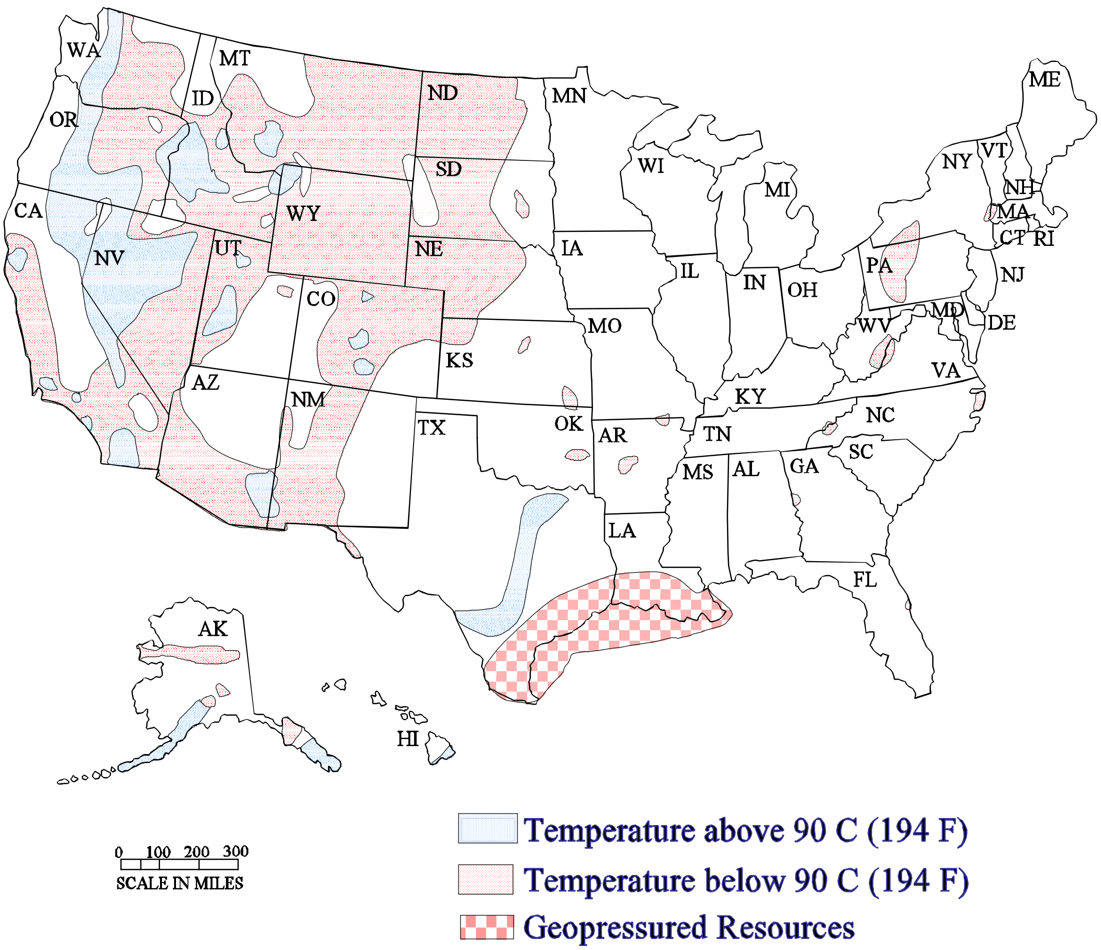

Figure 2. Generalized distribution of geothermal resources in the United States.

Currently, the main GHP use is in mid-western and southeastern states; however, the geothermal heat pump industry is poised for tremendous growth in the entire nation during the 1990s, with the opportunity to displace 2.7 Quads of energy by the year 2030 (EIA, 1990). Unfortunately, there is a lack of data and understanding by utilities and the public as to the long-term benefits of ground-source heat pumps. Thus, to capitalize on this opportunity, the following is recommended:

1. Develop a regulatory strategy of integrated resource planning with environmental externalities to permit utilities to profit from investments in increased energy efficiency as well as from increased capacity (i.e., demand-side rather than supply-side management).

2. Conduct a joint DOE/GHP industry R&D program to reduce the cost of installing ground-coupled loops.

3. Provide education for utilities, contractors and the public on the benefits, uses and installation of heat pumps.

4. Compile data on soil and groundwater conditions for potential uses and provide demonstration projects to collect data, and to illustrate the use of heat pumps.

<u>**Geothermal Energy for Buildings**</u> **(other than by heat pumps)**

Geothermal energy for space heating of residential, commercial and institutional buildings is primarily applicable in the western half of the United States (see Figure 2). The potential for geothermal space heating is large. Geothermal resources (>120ºF) are collocated within 5 miles of 254 western cities that have a combined heat load estimated at 65 trillion Btu per year (19 million BOE). Geothermal district heating systems, currently operating in 20 cities, save customers 30 to 50% in heating bills compared to conventional fuels.

A showcase of a successful geothermal district heating system is that of the city of San Bernardino, California. The system consists of two production wells with an average flow of 1,375 gpm of 130ºF water in 12 miles of insulated pipelines. The system currently serves 33 buildings including government centers, the County Jail, the new Blood Bank facility and other private buildings. Other uses are heating for the anaerobic digester at the sewage treatment plant and disinfections for the City Animal Shelter. In all, the buildings used 37.6 billion Btus (11 thousand BOE) in the FY 92. By the end of FY93, there will be three more facilities connected to the heating district, including two large laundries, that will triple the total heat load of the district.

The Department of Defense is looking for a place to locate a new accounting facility. San Bernardino made a proposal that included three locations in which geothermal energy could service the facility. Using geothermal energy would save approximately 17.8 billion Btu per year (5.2 thousand BOE), or about $90,000 first-year operating costs.

San Bernardino's successful implementation of a geothermal space heating system in its mild climate is noteworthy. This development demonstrates the very favorable prospects in the hundreds of other geothermal sites located in much colder climates, such as Mammoth, California and Klamath Falls, Oregon. This technology represents considerable savings to customers while helping to meet clean air standards, especially in the Los Angeles Basin and scenic recreational areas.

To date, most geothermal direct use projects have been developed at or near previously proven resources (hot springs or areas of historic use). If geothermal direct use is to achieve even a small percentage of its great potential, two issues must be addressed:

- Energy engineers must be comfortable with direct use design, and
- The vast inventory of "masked" or hidden resources must be successfully accessed.

Engineering consultants have a large impact upon the choice of heating systems a building owner or process operator selects. If they are unfamiliar with a given technology, they will not promote its use. The presence of a proven and reliable source of technical advice to the consultant is critical to their initial involvement with an unfamiliar resource.

A second factor significantly inhibiting direct use geothermal development is the high risk involved in drilling wells. Most direct use projects are much smaller in size, cash flow, and total investment than geothermal electric power projects. As a consequence, it is not possible economically to support the level of investment necessary for an exploration program to develop the geothermal resource. Even with the support of the owner and design consultant, this risk prevents the project from going forward. A program to reduce this risk would stimulate much wider use of geothermal resources.

The exploitation of geothermal energy could take a major step forward, given the appropriate support on a national level by:

1. Providing a federally-funded technical assistance program designed to introduce the potential user and engineering consulting community to geothermal direct heat.

2. Developing a program of cost-sharing for exploration and drilling of geothermal prospects specifically for the development of low- and moderate-temperature geothermal resources areas. This program could include provisions that successful projects would repay some or all of the federal funding that led to their development.

3. Initiating research work what would encompass examination of the exploration methods (geology, geochemistry, geophysics, geohydrology, etc.) used and how well they work, development and testing of new improved exploration methods, development and testing of improved drilling techniques, and similar topics. In fact, present direct-use projects are producing data on reservoir response that is only being examined sporadically due to lack of R&D funding.

Geothermal Energy for Industry

Geothermal direct use for industry, which primarily occurs in the western half of the United States, includes: enhanced oil recovery, gold mining, food processing, greenhouse heating, and aquaculture. The estimated geothermal energy use of industry to date is 11,800 billion Btu per year (3.4 million BOE), with enhanced oil recovery as the predominant application (84%). The direct use industry has grown over six fold during the 15-year period from 1970 to 1985.

Figure 3 identifies other industrial and agricultural applications that can use geothermal energy.

Enhanced oil recovery opportunities that are collocated with geothermal resources represent a tremendous opportunity for geothermal energy. Possible fields exist in the Los Angeles Basin and the Gulf Coast.

Geothermal food processors, such as the vegetable dehydration plant at Brady, Nevada, can utilize sites with resource temperatures greater than 220°F for dehydration of fruits and vegetables. There are many sites in this temperature range near agriculture production areas in western states.

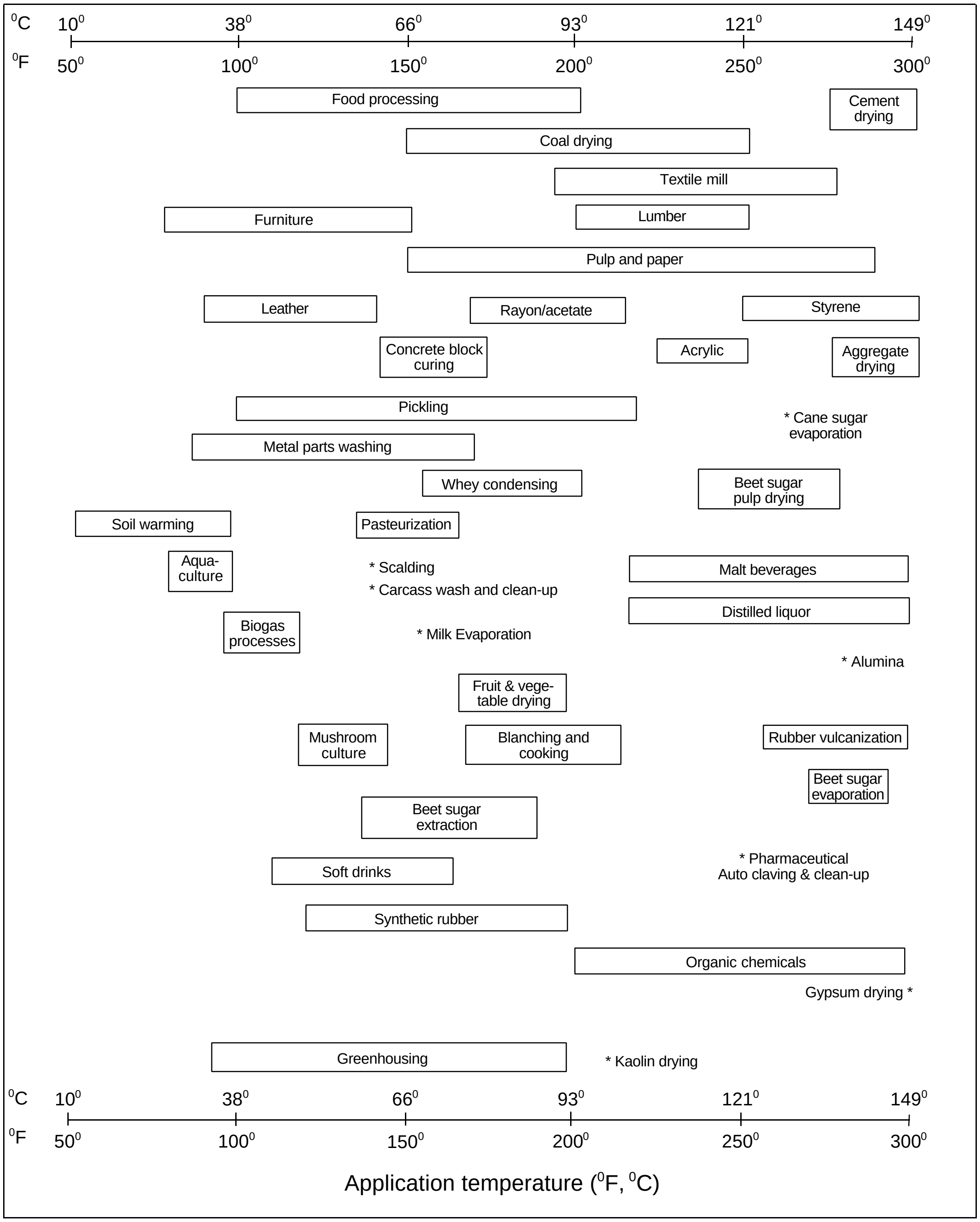

Figure 3. Application temperature range from some industrial processes and agricultural applications.

Greenhouses can utilize geothermal temperatures as low as 100°F. There are many such resources, but little is know about them. Assuming federal programs are instituted to provide information and assistance, the growth from a current use of 380 to 2,400 billion Btu per year (110 to 700 thousand BOE) is estimated by the year 2010.

Aquaculture is one of the fastest growing industries. Catfish processing increased 21% last year. Although, only a small part of that increase is geothermal, it is well known that growth rates and food conversion are greatly enhanced with geothermal aquaculture.

Geothermal aquaculture projects have obtained 50 to 300 percent growth rate increases in aquatic species as compared to solar heated ponds. Aquaculture can utilize geothermal resource temperature as low as 70 to 80°F, and can be cascaded from other uses. Current geothermal aquaculture use is 970 billion Btu per year (280 thousand BOE) at 18 sites and by 2010, this could increase to 7,500 billion Btu per year (2.2 million BOD). An active program of resource definition to assure availability of adequate quality water, demonstration of technology and dissemination of information to the aquaculture industry would be necessary to stimulate growth.

The most recent industrial use is to increase the efficiency of heap leaching for gold and other minerals in Nevada. The use of geothermal energy provides more efficient leaching because of higher temperature and increases the climate "window" for leaching. The gold and other minerals were deposited by geothermal water–epithermal deposits–and in some cases, geothermal heat is still available. At least 10 applicable sites have been located in Nevada and similar geologic conditions occur in other states.

International

Beginning with boric acid industry in the early 1800s in the Tuscany region of Italy, the geothermal direct use applications have been numerous throughout the world. The most noted uses are in Iceland where geothermal district heating is provided to 55% of the population, and a diatomaceous earth drying plant provides filter material for beer production in Germany. Geothermal district heating is also extensive around Paris and Aquitaine basins in France where 10,000 apartments are online. Other uses include providing energy to a pulp and paper plant in New Zealand, extensive greenhouse heating and grain drying in Hungary, fish and alligator raising in Japan and China, and bathing and health spas use in Czechoslovakia and Japan (Freeston, 1990).

The U.S. geothermal industry has the potential to export their expertise and equipment to other countries. There is an increasing awareness abroad to develop indigenous energy resources as indicated in part by inquires and request for assistance to the Geo-Heat Center and the National Geothermal Association. The U.S. commercial sector can provide this assistance and products which would help our balance of payments. The development of this industry abroad could assist in the reduction of pollution from inefficient fossil fuel plants in countries such as Poland and Romania.

Recommendations

It is important to encourage the development of geothermal energy in direct use applications now. If opportunities are missed, then systems using less efficient, polluting and/or foreign sources of energy will be employed. Once installed, they are difficult to replace until fully amortized. Thus, new subdivisions, office buildings and other applications must be encouraged to use geothermal energy now. It is estimated that federal funding in the range of $3 to $5 million per year is needed to implement this program.

Thus, in the coming years, the exploitation of geothermal energy could take a major step forward given appropriate encouragement at the national, state and local level, resulting in progress in three major areas. In particular:

1. Providing technical assistance and R&D programs to aid in the analysis and implementation of direct use projects, and to establish an infrastructure of geothermal expertise. An R&D program will help solve technical problems and reduce costs of developing, designing and operating geothermal projects.

2. Establishing a cost-shared program of exploration, evaluation, and confirmation of low-to-moderate temperature geothermal resources collocated with cities in western and mid-western states that have potential for district heating and other applications.

3. Encouraging development of geothermal (ground-source) heat pumps in cooperation with public utilities and support R&D programs to reduce the cost of installing ground-coupled loops.

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