GEOTHERMAL DIRECT HEAT APPLICATION POTENTIAL

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Abstract

The geothermal direct-use industry growth trends, potential, needs, and how they can be met, are addressed. Recent investigations about the current status of the industry and the identification of institutional and technical needs provide the basis on which this paper is presented. Initial drilling risk is the major obstacle to direct-use development. The applications presented include space and district heating projects, heat pumps (heating and cooling), industrial processes, resorts and pools, aquaculture and agriculture.

Introduction

The use of low- and moderate-temperature (50 to 300°F) geothermal resources for direct-use applications has increased significantly since the late-1970s. The oil price shocks of the 1970s revived interest in the use of geothermal energy as an alternative energy source. Accordingly, the U.S. Department of Energy (USDOE) initiated numerous programs that caused a significant growth of this industry. These programs involved technical assistance to developers, cost sharing of demonstration projects, resource assessment, loan guarantees, support of state resource and commercial activities, and others. Also adding to the growth were various state and federal tax credits. The use of groundwater heat pumps contributed to the growth, starting in 1980.

In January 1989, for the first time in a decade, the United States imported more crude oil and petroleum products than its domestic wells produced. As dependence on imports increases, the threat of future disruptions brought on by supply interruptions increases. The country needs a serious program to develop alternative energy resources and incentives to encourage energy conservation. It is crucial at this time that feasible ways be found to diminish this country's rising dependence on oil imports, preferably through a comprehensive approach to conservation and developing cost-effective alternative energy sources (excerpted from a *Los Angeles Times* editorial).

Direct-Use Installations

Direct heat use of geothermal energy in the United States is recognized as one of the alternative energy resources that has proven itself technically and economically, and is commercially available. Developments include space conditioning of buildings, district heating, groundwater heat pumps, greenhouse heating, industrial processing, aquaculture, and swimming pool heating. Forty-four states have experienced significant geothermal direct-use development in the last ten years. The total installed capacity is 5.8 billion Btu/hr (1,700 MW_t), with an annual energy use of over 18,000 billion Btu/yr (5 million barrels of oil energy equivalent). These data are based on an extensive site data gathering effort by the Geo-Heat Center in the spring of 1988, under contract to the U.S. Department of Energy (Lienau, 1988). These energy use values are graphically displayed in Figure 1, showing the significant increase in the use of geothermal energy for direct use, especially after 1970. The annual compound growth rate for the industry from 1940 to 1970 was about 3%, from 1970 to 1985 about 13%, and from 1985 to 1990 it is estimated at 6%. Of course, the oil price shocks of the early-1970s and federal incentives account for the increase during the 1970 to 1985 period.

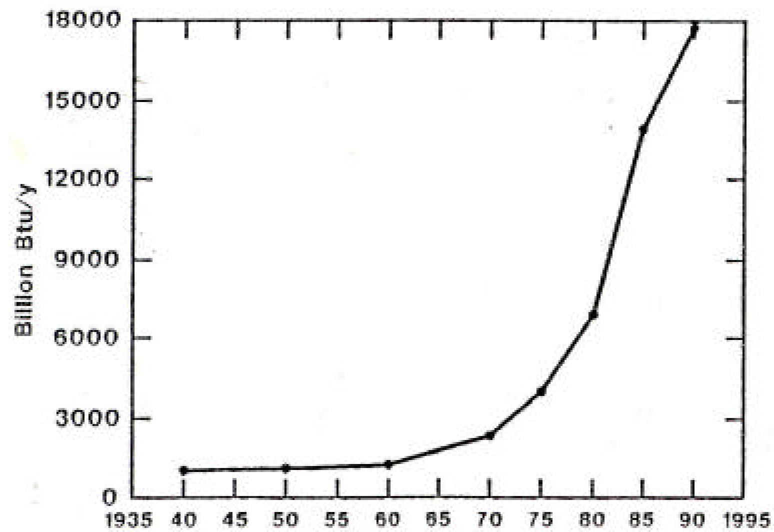

Figure 1. Direct-use energy on-line from 1940 to 1990.

Figure 2 shows the projects on-line, separating heat pump installations from the other direct-use applications. Most people think of geothermal energy as a western states' resource; however, there are significant projects developing this resource for space conditioning and district heating where low-temperature (40 to 70°F) groundwater aquifers exist throughout the entire United States. Groundwater and earth-coupled (vertical configuration) heat pump systems depend upon the average groundwater temperature. The recent phenomena of heat pump installations expects a growth rate of about 50 percent per year through 1990, according to the heat pump industry. Approximately 66,100 groundwater heat pump installations are presently installed.

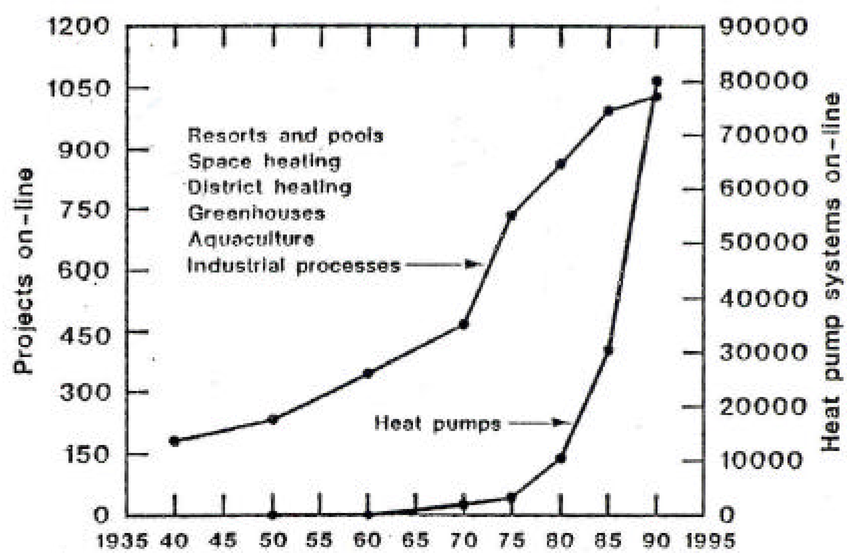

Figure 2. Direct-use projects on-line between 1940 and 1990.

Table1 gives the distribution of use according to application, which includes the largest single application, the secondary oil recovery operations in Montana, North Dakota, South Dakota and Wyoming.

Table 1. United States Geothermal Use by Application in 1988

Application	Quantity (each)	Capacity (10^9 Btu/hr)	Annual Energy (10^9 Btu/yr)
Industrial	16	1,435	9,949
Heat Pumps	66,135	3,202	3,602
Resorts/Pools	114	234	1,452
Aquaculture	180	180	970
Greenhouses	35	297	852
Space Heating	829	231	744
District Heating	23	283	700
	67,170	5,862	18,270

The principle direct-use projects, their resource temperature, and annual energy use, are identified in Table 2, with the largest energy users listed first.

Geothermal Direct-Use Potential

Studies by the U.S. Geological Survey state that the resource base for geothermal energy is very large (Muffler, 1978 and Reed, 1982). There are 1,324 identified hydrothermal and conduction-dominated geothermal systems. The estimated wellhead energy for low-to-moderate temperature (<90 to 150°F) resources, assuming a recovery factor of 0.24, is 249.5 quadrillion Btu (quads). The estimates exclude an enormous amount of shallow groundwater in the United States. Industry recognizes that such shallow waters may be useful as a source of energy for heat pumps.

The potential to use geothermal energy for district heating in the United States is very large. A study of only eight western states identified hydrothermal sites within five miles of 373 cities, with a combined population of 6,720,000 persons. Resource temperatures >120°F, which are suitable for direct use in district heating systems, were found to exist near 83 cities (1,076,000 population). The remainder would require large-scale heat pump applications. The combined heat load for all cities in the eight states (exclusive of industrial loads) is estimated at 132,600 billion Btu/yr or 38 million bbl of oil/yr (Allen, 1980).

For example, using a grant from the U.S. Department of Housing and Urban Development, and existing warm water (84°F) resources, the city of Ephrata, Washington, is demonstrating the feasibility of heating the Grant County Courthouse and low-income HUD family residences. The demonstration project has become a nucleus of a heating district. The project will tap a cross town transmission main, supplied by 2,000-ft wells, to fee the primary heat exchanger of a conventional 100-ton water-to-water heat pump. On a single pass through the heat pump, the water temperature will drop 10°F and be returned to the main for domestic consumption. Hot water at 120°F will be provided to the buildings for heating. The project is a unique blend of existing resources and technology and demonstrates that local governments can approach energy needs in an innovative way.

Table 2. Principle Direct-Use Systems in the United States

Application	Resource Temperature (^{O}F)	Annual Energy Use (10^9 Btu/yr)
Industrial		
Enhanced Oil Recovery	200	9,480
MT, ND, SD, WY		
Heap Leaching		
Round Mountain Gold Corp., NV	186	263
Pegasus Gold Corp., Cary, NV	238	40
Food Drying		
Geothermal Food Processors, NV	270	86
Mushroom Growing		
Oregon Trails Mushrooms, OR	235	54
Heat Pumps (Heating)		
Florida, all of the state	75	839
Michigan, all of the state	47	355
Indiana, all of the state	54	335
Resorts/Pools		
Payne's Fountain of Youth, WY	125	665
Hot Springs State Park, WY	135	478
Hunt's Ash Springs, NV	97	177
Aquaculture		
Hot Creek Hatchery, CA	61	201
Fish Breeders of Idaho, ID	90	174
Hyder Valley, AZ	105	140
Greenhouses		
Troy Hygro, UT	230	471
Burgett Floral Greenhouses, NM	245	65
Utah Roses, UT	124	45
High Country Roses, MT	151	33
Space Heating		
Peppermill Casino, NV	127	63
Residences (505 each), Klamath Falls, OR	200	44
Residences (200 each), Reno, NV	180	32
Merle West Medical Center, Klamath Falls, OR	191	24
District Heating		
Mammoth Lakes, CA	300	120
Litchfield Correctional Center, CA	170	79
Boise City, ID (two systems)	170	73
San Bernardino, CA	138	45

In addition, there is an extremely large potential of using identified low-temperature resources for greenhouses and aquaculture projects. For example, a 72ºF thermal spring in Montana produces 72,000 gpm and an aquaculture facility is being considered for raising sturgeon. Cascading geothermal effluents from geothermal power plants to industrial processes, greenhouses and then aquaculture facilities is another potential use that would improve the efficiency of the geothermal resource use.

Perhaps the largest potential use of geothermal energy is for groundwater heat pumps. Both geothermal gradients and heat from the sun (the earth is a massive collector that absorbs and stores heat from the sun) contribute to elevated groundwater temperatures. Groundwater heat pump systems have national appeal since water temperatures down to 39°F can be used in heat pump systems. Electric utilities in many areas of the country are strongly promoting the use of ground-source heat pumps and in part, this accounts for their increased development. Ground-source units, as compared to air-source units, are more efficient (COP) and provide better performance since the heat source remains at nearly a constant temperature all year.

Geothermal energy, because of its environmentally benign nature, is an ideal source whose use will help mitigate the causes of potential global warming. As the knowledge and concern increases about the effects of global warming, the need and desire, to use geothermal energy for direct uses (and power production) is expected to increase significantly.

Geothermal Direct-Use Guidebook

It is in this setting of increasing usage of geothermal energy for direct uses and a significant identified resource base, that a *Geothermal Direct-Use Engineering and Design Guidebook* is issued.

The Guidebook contains 20 chapters prepared by numerous contributors with extensive experience in the use of geothermal energy for direct-use applications. A great deal of information has been gained from the development and operation of many projects, and that experience is incorporated in the Guidebook to provide current state-of-the-art technical data and institutional information. Lessons learned from various heating, agribusiness, aquaculture and industrial projects, including those developed as a result of U.S. Department of Energy's Program Opportunity Notices, provide the background for the Guidebook (Lunis, 1989).

Institutional and Technology Needs

The major obstacle to the development of geothermal energy is the initial drilling costs, which combined with the geological uncertainties, generate financial risks of considerable importance. The relatively long lead time between deciding to invest and any return on operations adds to the barriers to develop a sometimes very economic energy source.

There is a need for a serious federal program to help overcome this initial risk, which is particularly significant for the private sector, and to encourage the development of the techniques to reduce costs and resolve some of the technical problems which can be encountered with injection wells, well production pumps, piping systems, etc.

Direct-use resource projects have similar generic requirements for the project to be technically and economically feasible as do electric generating projects. The direct-use projects, however, often have a much smaller economic base, and require analyses and field work that is downscaled from similar electric generating projects. This introduces special problems in the evaluation of the resources and the degree to which the project can be examined or evaluated. Currently, there are many potential direct-use sites in the United States that are in the investigation stage. Most of those sites have almost no resource data. This requires a substantial part of the project effort to be expended in developing very preliminary resource information. Therefore, there is a need to define and understand a large number of low- and moderate-temperature resources around hundreds of population centers. Heat delivered to district or private heating systems is the most important application.

Two programs, which have been highly successful in reducing the initial risk and encouraging widespread adoption of geothermal space heating projects are: the European Community Energy Demonstration Program, and the California Energy Commission Resource Development Program.

The European Community Energy Demonstration Program, which began in 1978, has a goal of not just to achieve a successful demonstration; its much broader objective is to encourage the widespread adoption of the demonstrated technology wherever appropriate in the community. Projects supported under the program act as a link between the research and development phase, and the later investment phase. Inherent risks are often still too high fo developers to accept unaided. The Community overcomes this problem by providing some necessary risk capital, which can also act as a catalyst for involvement by other institutional investors.

The European Community geothermal program has funded 120 projects in 11 countries, representing 9.4% of the total investment for all projects. Of these 120 projects, 53 have completed the phase supported by the Community, and 20 of these projects are now operational. Total energy substituted amounts to about 70,000 ton of oil equivalent per year (TOE/yr), mainly for space heating, but with some electricity generation (Commission of European Communities, 1988).

The California Energy Commission (CEC) has a geothermal grant and loan program for local jurisdiction designed to reduce the risk of developing geothermal resources. The resource development category includes projects to assess and explore for geothermal resources; to drill production and injection wells. According to the manager of the CEC program (Smith, 1989), a more effective method of encouraging widespread adoption would be to reduce drilling risks of projects developed by the private sector.

This successful program, which began in 1981, has received 200 proposals of which 73 have been funded, valued at $17,449,000. Of these, 14 projects are operational and are saving approximately 5,000 TOE/yr and planned activities in the coming year could increase this to about 12,000 TOE/yr.

There is a need to encourage and establish cooperative agreements between geothermal power plant operators and developers of greenhouse and aquaculture projects. This would eliminate the drilling risk of the direct-use projects and at the same time, improve the overall efficiency of the geothermal power plants.

Conclusions

The results of federal programs in the early 1980s are very encouraging and, for many projects commercial exploitation, is not a reality. The economic conditions and the competitiveness of geothermal energy development have declined in recent years, resulting from the fairly abundant supply of conventional energy resources and their price trends.

As dependence on the import of crude oil increases, there is a need for a serious program to develop alternative energy resources and encourage energy conservation. There is an enormous potential of using geothermal resources for district heating. However, there is a need for federal support (cost share) of the drilling phase for the exploitation of new geothermal reservoirs, thus mainly covering the drilling risk. This approach has proven to be very efficient in the European Community and California in triggering geothermal activity.

In the coming years, the exploitation of geothermal energy could take another major step forward, given the appropriate encouragement at the national level, and progress in a number of areas, in particular:

- Experimental drilling in new and little known areas to overcome the initial risk;
- Evaluation of low- and moderate-temperature resources near hundreds of population centers that have potential for district heating;
- Encourage cascading from geothermal power plants to industrial processes (such as heating and drying), greenhouse and aquaculture projects; and
- Resolve technical problems (injection wells, well production pumps, piping systems, etc.).

References

Allen, E., 1980. "Preliminary Inventory of Western U.S. Cities with Proximate Hydrothermal Potential." VBB Allen, Salem, OR.

Commission of European Communities, 1988. "Community Demonstration Program in the Sector of Geothermal Energy," Publication XVII/33/88-EN. Brussels, Belgium.

Lienau, P. J.; Lund, J. W. and G. Culver, 1988. "Geothermal Direct-Use Developments in the United States." OIT Geo-Heat Center report to USDOE, Klamath Falls. OR.

Lunis, B. C. and P. J. Lienau, 1988. Geothermal Direct-Use Engineering and Design Guidebook Available for an Expanding Market. Presented at the DOE Program Review VII, San Francisco, CA.

Muffler, L. J. P, editor, 1979. "Assessment of Geothermal Resources of the United States - 1978," U.S. Geological Survey Circular 790, Reston, VA.

Reed, M., editor, 1982. "Assessment of Low-Temperature Geothermal Resources of the United States - 1982," U.S. Geological Survey Circular 892, Reston, VA.

Smith, M., 1989. Personal communication. California Energy Commission, Sacramento, CA.