GEOTHERMAL DIRECT-USE IN THE UNITED STATES IN 2000

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INTRODUCTION

Geothermal energy is estimated to currently supply 19,429 billion Btu/yr (20,478 TJ/yr - 5,689 GWh) of heat energy through direct heat applications in the United States. The corresponding installed capacity is estimated at 5,373 MWt. Of these values, direct-use is 8,044 billion Btu/yr (8,478 TJ/yr - 2,355 GWh) and 573 MWt and geothermal heat pumps the remainder. It should be noted that values for the capacity and the energy supplied by geothermal heat pumps are only approximate since it is difficult to determine the exact number of units installed and most are sized for the cooling load, thus they are oversized in terms of capacity for the heating load (except possibly in the northern U.S.).

Figure 1 shows a comparison of the direct heat use for the various applications for 1990, 1995 and 2000. Figure 2 shows the growth of the various direct-use applications since 1975 (excluding heat pumps). Most of the applications experienced some increase in use; however the largest annual energy growth has been in geothermal heat pumps. Aquaculture has the largest annual energy growth rate of the direct-use categories, increasing in annual use by 16.9% compound per year over the past five years. From 1990 the growth rate for direct-use was 8.3% annually and for geothermal heat pumps estimated at 7.7% annually for a total of 7.9% annually.

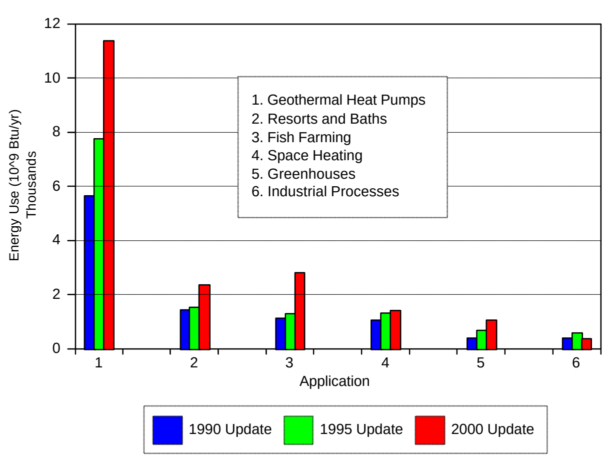

Figure 1. Direct Heat Utilization in the United States compared at 1990, 1995 and 2000.

Resorts and spa use and development has actually remained fairly constant with only slight growth - most of the increase is due to better reporting of the data. There has been a major decrease in the industrial section, as the gold and silver heap leaching projects in Nevada are no longer using geothermal energy. In addition, the lithium-bromide chiller used on the Oregon Institute of Technology campus has been replaced with an electric chiller (due to the low efficiency of the geothermal system), thus there is no direct-heat cooling in the U.S. (except for geothermal heat pumps). Today, 35.0% of the annual energy use for direct-use is in the aquaculture industry, 29.4% is in bathing and swimming (resort and spa pool heating), 17.5% in space heating (including district heating), 13.4% in greenhouse heating 4.7% in industrial processing, including agriculture drying and snow melting as shown in Figure 3a. If geothermal heat pumps are included, then they contribute 59% to the annual energy use, and direct-use contributes 41% as shown in Figure 3b.

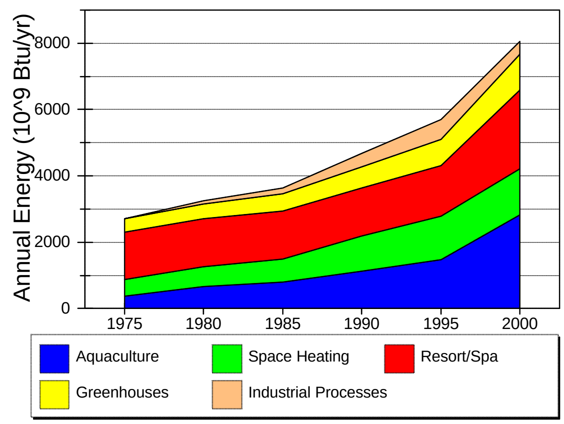

Figure 2. Growth of the U.S. direct energy utilization by category without heat pumps.

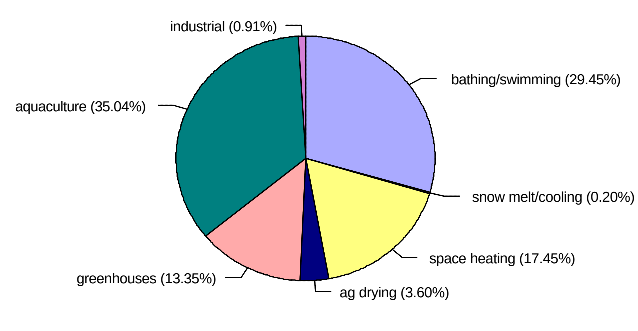

Figure 3a. 2000 direct-use percentages by category based on annual energy use.

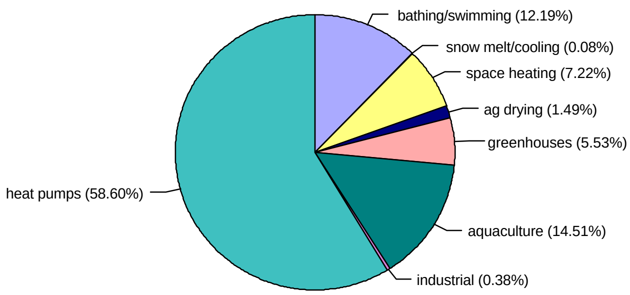

Figure 3b. **2000 direct-use and geothermal heat pump annual energy use percentages.**

DIRECT USE DEVELOPMENT OVER THE PAST FIVE YEARS

There were 27 new projects identified in 7 states and 10 existing projects were expanded a significant amount over the past five years The new projects are mainly aquaculture pond and raceway heating in the Imperial Valley of California and along the Snake River Plain in Idaho, and greenhouses in Montana and Utah. The expanded projects include the Klamath Falls and Oregon Institute of Technology district heating projects, six greenhouse projects in California, Idaho and New Mexico, and two aquaculture projects in the Imperial Valley of California. Two major industrial projects, both silver and gold heap leaching in Nevada no longer use geothermal energy in their process, due to the expense of royalty payments for geothermal energy from federal lands. The remainder of the increase was due to better reporting of space heating and resort/spa pool heating.

During this period, the thermal capacity of the direct heat projects increased by 143 MWt , representing an annual energy utilization of 2,634 billion Btu/yr (2,776 TJ/yr) (Lienau, et al, 1995). Geothermal heat pumps increased in capacity by 2,956 MWt, representing an annual energy utilization of 3,617 billion Btu/yr (3,812 TJ/yr) (Lienau, et al., 1995). A mini-heating district in Midland, South Dakota has been added as a new project, even though it was started in 1969. This project was unknown to the geothermal community until 1997 (Lund, 1997).

The majority of the increase in direct utilization since 1995 is in aquaculture (Imperial Valley of California and Snake River Plain of Idaho), greenhouse heating, and snow melting (Klamath Falls, Oregon). The increase in space heating and resorts/spa is mainly do to refinement of the data, since most of these projects already existed and have minor increases in size.

A summary of the direct utilization in the United States is presented in Table 1.

TABLE 1. DIRECT-USE BY INDIVIDUAL STATES

State	Numbers of sites	Installed Capacity MWt	Annual Use 10^9Btu	Annual Use TJ	Load Factor
Alabama	2	1.74	41.6	43.9	0.80
Alaska	14	4.50	86.0	90.7	0.64
Arkansas	2	1.22	27.7	29.2	0.76
Arizona	12	21.54	277.2	292.2	0.43
California	100	114.51	1908.2	2011.2	0.56
Colorado	39	29.77	526.5	554.9	0.59
Georgia	3	1.49	31.2	32.9	0.70
Hawaii	1	0.29	2.0	2.1	0.23
Idaho	73	101.60	1225.8	1292.0	0.40
Louisiana	2	1.74	41.6	43.9	0.80
Mississippi	2	1.74	41.6	43.9	0.80
Montana	34	15.47	275.8	290.7	0.60
New Mexico	13	54.47	643.6	678.4	0.40
Nevada	332	68.83	1035.3	1091.2	0.50
New York	2	0.88	11.5	12.1	0.44
Oregon	628	59.48	585.6	617.2	0.33
S. Dakota	6	8.61	118.4	124.8	0.46
Texas	3	4.04	26.0	27.4	0.22
Utah	17	51.10	425.3	448.3	0.28
Virginia	1	0.32	2.9	3.1	0.27
Washington	6	1.61	36.2	38.2	0.75
West Virginia	1	0.12	3.5	3.7	0.80
Wyoming	21	28.33	670.1	706.3	0.79
TOTAL	1314	573.40	8043.6	8478.2	0.47

Aquaculture Pond and Raceway Heating

The largest increase in geothermal direct-use in the United States in the past five years was in aquaculture pond and raceway heating. Ten new pond heating projects were recently identified in the Imperial Valley of California along with the expansion of two existing projects (Rafferty, 1999). Approximately 8.06 million pounds (3.66 million kg) of Tilapia, catfish and hybrid striped bass are raised here annually. Most are shipped live to markets in Los Angeles and San Francisco. A second area identified as having a significant increase in aquaculture projects is along the Snake River Plain of southern Idaho. Seven new projects were identified in this area, adding an additional 2.20 million pound (one million kg) of Tilapia and catfish in annual production. These installations use cascaded water in raceways for raising their fish, whereas in the Imperial Valley, ponds and tanks are the most common. Fish from these sites are also shipped live to cities in Canada and the northwestern US states. In addition, aquaculture projects using 70 to 90ºF (21 to 32ºC) water are found in the southern states of Texas, Arkansas, Louisiana, Mississippi, Alabama and Georgia. It is difficult to calculate the exact energy used by the various installations, thus based on data from a limited number of operations, the remaining are proportioned according to the amount of fish raised annually.

Geothermal Heat Pumps

Geothermal heat pumps has steadily increased over the past five years with an estimated 45,000 units installed in 1997 of 3.4 ton (12 kW) size capacity (Ragnarsson, 1998). Of these, 46% are vertical closed loops, 38% horizontal closed loop and 15% open loop systems. Projections for the future are that the growth rate will increase about 10% annually, so that by 2010 an estimated 120,000 new units would be installed in that year. It is estimated that 400,000 units are presently installed in the U.S., thus, this rate would add an addition 1.1 million units for a total of about 1.5 million units by 2010. Using a COP of 3.0, and a 1,000 full load hours per year in the heating mode, the 400,000 units remove approximately 11,400 billion Btu/yr (12,000 TJ/yr) from the ground. The cooling mode energy is not considered, since this rejects heat to the ground; however, the cooling mode does replace other forms of energy.

The majority of the geothermal heat pump installations in the U.S. are in the mid-west and southern states (from North Dakota to Florida). There have been few installation in the west, due to some environmental concerns and lack of general knowledge on the subject by HVAC companies and installers. Hopefully recent geothermal heat pump seminars, offered by the Geo-Heat Center, will improve the understanding and use of this technology in the west.

Space and Pool Heating

Data from space heating (other than district heating) and for pool heating at resorts and spa were updated. We lacked information for approximately 20% of these sites, and thus estimates were made for the missing data based on the knowledge and experience of the authors. This increase, in most cases, is not due to new installations, but reflects the gathering of better data. The other space heating category that increased by a significant percentage was snow melting. These systems were recently added in Klamath Falls and include new sidewalk and handicap ramp heating on the Oregon Institute of Technology campus (2,700 ft^2 - 250 m^2) and sidewalk heating in downtown Klamath Falls (94,000 ft^2 - 8,700 m^2) (Boyd, 1999 and Brown, 1999). In addition, a major highway geothermal snow melting systems in Klamath Falls, that had been used for 50 years, was replaced in the Fall of 1998 and is used to heat approximately 22,000 ft^2 (2,000 m^2) of concrete pavement (Lund, 1999).

Summary

The distribution of capacity and annual energy use for the various direct utilization categories is shown in Table 2. These figures are based on the best estimates made by the authors. We also feel that anywhere from 10 to 20% addition geothermal direct energy use is unreported throughout the country, due to their small size and often isolated location.

The total direct-use and geothermal heat pumps energy use in the United States is equivalent to savings of 5.6 million barrels (0.84 million tonnes) of fuel oil per year. This produces a savings of between 330,000 (natural gas) and 1,650,000 (coal) tons of carbon pollution annually if the replacement energy was provided by electricity and about half this amount if used directly in heating systems (35% vs 70% efficiency). If the savings in the cooling mode of geothermal heat pumps is considered, then this is equivalent to and additional savings of 3.3 million barrels (0.49 million tonnes) of fuel oil per year or from 190,000 (natural gas) to 960,000 (coal) tons of carbon pollution annually.

TABLE 2. SUMMARY OF GEOTHERMAL DIRECT-USE

		Installed	Annual		
	Number of	Capacity	Energy		Use
	Capacity				
Use	**Installations**	**(MWt)**	**10^9Btu**	**TJ**	**Factor**
Space Heating	975	83	811	855	0.33
District Heating	18	99	592	624	0.20
Aquaculture	53	136	2,819	2,971	0.69
Greenhouses	37	119	1,074	1,132	0.30
Agriculture Drying	3	20	290	305	0.49
Industrial Processing	4	7	73	77	0.35
Resorts/Spas/ Pools	219	107	2,369	2,497	0.74
Snow Melting	5	2	16	17	0.27
Subtotal	1,314	573	8,044	8,478	0.47
Geo. Heat Pumps	400,000	4,800	11,385	12,000	0.19
Total		5,373	19,429	20,478	0.25

GEO-HEAT CENTER TECHNICAL ASSISTANCE

A study by Rafferty (1998) illustrates a relationship between the "explosive" growth in the geothermal heat pumps (GHPs), aquaculture and greenhouse industries' use of geothermal energy and the Geo-Heat Center's technical assistance in these area. A significant part of our activity, approximately 30%, are requests for GHP technical assistance from individuals planning a large home in a rural setting in a moderate-to-cold climate (typically in the Midwestern and Eastern states). This suggests that our activity in this area is an accurate reflection of the niche market currently served by GHP systems in the residential section and the large annual growth in new installations (between 40,000 and 50,000 units/year).

If we focus on technical assistance requests that are project related (not considering GHPs) they are almost equally distributed between aquaculture, district heating, greenhouses, space heating, small scale electric power and resorts/spas/pools. However, in the aquaculture pond and greenhouse heating area almost 60% of the requests are related to new projects (Figures 4 and 5). Outside of GHP, these areas, along with space heating, represent the bulk of our technical assistance work on new projects as shown in Figure 6. In aquaculture, most new geothermal applications are involved with Tilapia which is the fastest growing single species in aquaculture in general. Greenhouse projects are mainly used for growing flowers, as the vegetable market has difficulty competing with Latin American suppliers.

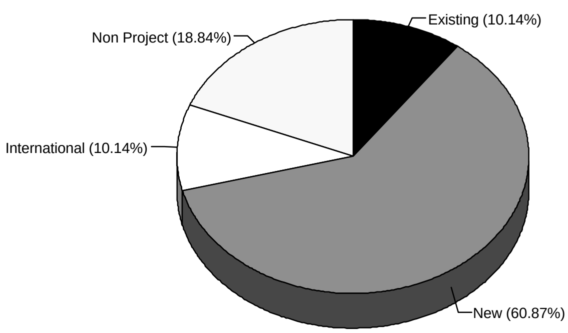

Figure 4. Distribution of Geo-Heat Center Technical Assistance Requests in Aquaculture.

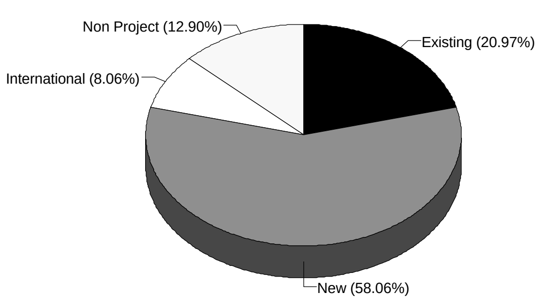

Figure 5. Distribution of Geo-Heat Center Technical Assistance Requests in Greenhouses.

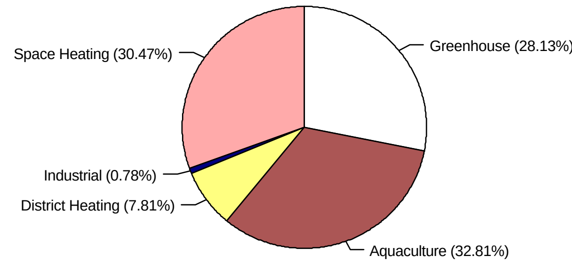

Figure 6. New Project Development Requests for Technical Assistance.

Thus, promoting greater use of geothermal resources for direct-use could best be done by targeting those areas in which there is already a clearly defined interest on the part of developers. Fortunately, both the greenhouse and aquaculture industries have well established professional and industry groups (and publications) to serve as information conduits for these efforts (Rafferty, 1998). The Geo-Heat Center staff is actively participating in professional trade shows and technical programs in these areas.

CONCLUSIONS

The growth in direct heat use has been approximately eight percent compounded annually over the past five years. This compares to the growth rate between 1985 and 1990. The period from 1990 to 1995 was lower at approximately six percent annually. Growth during 1995 to 2000 could have been higher, but competition from natural gas was a major factor. There are some positive signs on the horizon, in additional to the aquaculture growth, with proposed new district heating projects in Mammoth, CA, Reno, NV and Sun Valley, ID, and a zinc extraction plant in the Imperial Valley. The Reno project could expand district heating by 250 MWt with large commercial and industrial building heating (Lienau, 1997). The zinc project by CalEnergy Company, Inc., to be on line in mid-2000, will extract 33,000 tons (30,000 tonnes) of zinc annually from geothermal water using power from a new geothermal electric plant. The waste water from eight power plants (totaling 300 MWe), having 600 ppm of zinc will be utilized. In addition, the extraction of silica and manganese will also be considered.

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