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STATUS AND TRENDS OF GEOTHERMAL DIRECT USE PROJECTS IN THE UNITED STATES

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ABSTRACT

The United States is continuing to experience a significant growth rate in the use of low-and moderate-temperature geothermal resources for direct use applications, which is making an increasing contribution to the United States energy demands. This paper provides an overview of how and where geothermal energy is being used, the extent of that use, and what the development trends and concerns appear to be. The applications discussed include industrial processes, heat pumps (heating and cooling), pools and spas, aquaculture and agriculture applications, and space and district heating projects.

INTRODUCTION

Prior to about 1973, most geothermal direct use projects in the United States involved pool/spa applications and limited district and space heating systems. The oil price shocks of the 1970's 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 significant growth of this industry. These programs involved technical assistance to developers, the preparation of project feasibility studies for potential users, cost sharing of demonstration projects (space and district heating, industrial, agriculture, and aquaculture), resource assessments, loan guarantees, support of state resource and commercialization activities, and others. Also adding to the growth were various federal and state tax credits. The use of groundwater-source heat pumps contributed to the growth, starting in 1980.

The growth of direct use project development was quite closely monitored during the late 1970's and early 1980's when the USDOE program activities were extensive. Periodic updating of the status of the projects has been occasional and limited since that time. In order to obtain a better understanding of the current geothermal direct use market, the Oregon Institute of Technology Geo-Heat Center (OIT), under contract to the U.S. Department of Energy, launched an extensive data-gathering effort in the Spring of 1988. The results of that effort are incorporated into this paper. The Idaho National Engineering Laboratory (INEL) (also funded by the USDOE) and OIT, through their continuing contacts with the geothermal industry, including state energy offices, are familiar with development trends and concerns; this information is also presented.

CURRENT STATUS

The most significant findings resulting from the recent inventory of direct use projects are, the large number of installed groundwater-source heat pumps, primarily a phenomena of the 1980's, and the increasing use of geothermal energy for aquaculture applications. The installed capacity of swimming pools and spas using geothermal fluid is much larger than previously reported. These factors are incorporated into the comparison of direct use projects' summaries of previous investigations and the current inventory (Table 1). Other conditions contributing to the large increase of recorded geothermal direct use projects is the intensive effort by OIT in identifying heretofore unknown projects, and the increasing industry growth rate.

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Table 1. Comparison of Inventories of Installed Geothermal Direct Use Projects

	PRIOR SURVEY[a]			CURRENT SURVEY[b]		
		Annual Energy Use			Annual Energy Use	
Type	Quantity (Each)	kJ/y	(10^9 Btu/y)	Quantity (each)	kJ/y	10^9Btu/y
Industrial	7	10,154	9625	12	10,497	9950
Heat Pumps[c]	--	--	--	66,135	3,798	3600
Spa/Pools	85	253	240	114	2,242	2125
Aquaculture	8	422	400	17	981	930
Greenhouses	37	406	385	34	897	850
Space Heating	655	512	485	829	818	775
District Heating	20	427	405	20	596	565
	812	12,174	11,540	67,161	19,832	18,795

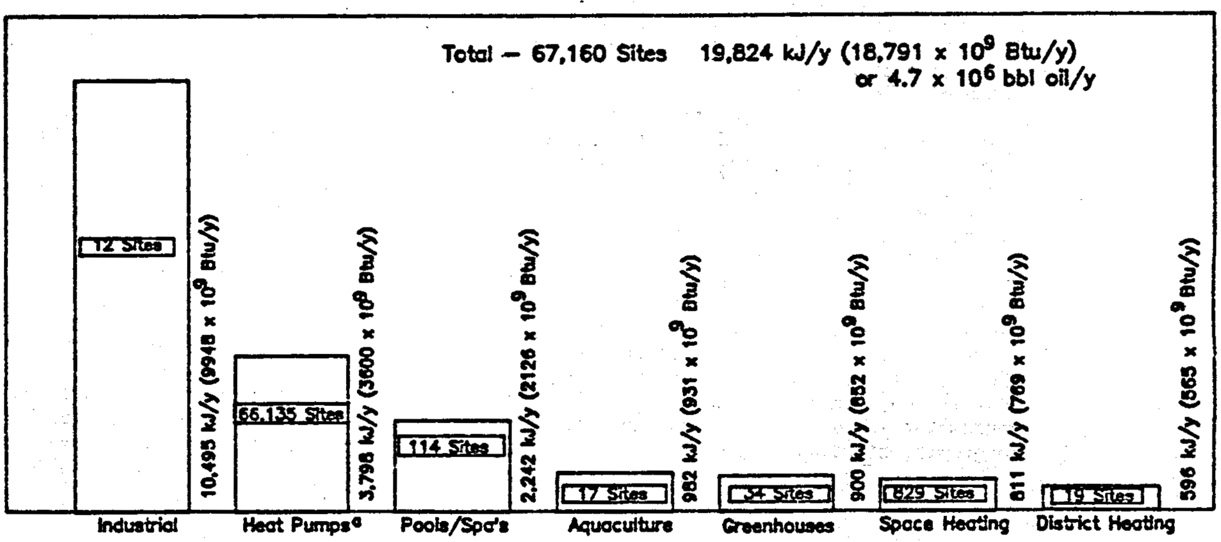
a. B. C. Lunis, Idaho National Engineering Laboratory, presentation made to the American Association of Petroleum Geologists, Rocky Mountain Section Meeting, September 15, 1987. The data base is restricted to earlier (1980) surveys that had limited updating.

b. P. J. Lienau, G. Culver, J. W. Lund, Geo-Heat Center, Oregon Institute of Technology, "Geothermal Direct Use Sites in the United States Interim Report", May 1988.

c. Includes heating loads. Almost 50,000 groundwater-source heat pumps are included; the remainder are vertically-installed earth-coupled systems. Horizontal earth-coupled systems (about 10,000) are not included.

CURRENT STATUS (Cont'd)

Operational direct use projects in the United States currently account for nearly 20,000 kilojoules per year (19,000 x 10^9 Btu per year), including an estimated 10,000 kilojoules per year (9,500 x 10^9 Btu per year) for enhanced oil recovery from the Williston Basin in central Wyoming (Figure 1). About an additional 4800 kilojoules per year (4500 x 10^9Btu/y) is heat into the ground as a result of cooling with heat pumps. Space conditioning of buildings, including the use of heat pumps, direct space heating and district heating, account for 53% of the estimated annual use, disregarding the enhanced oil recovery.



a. Heating only. Cooling (heat into the ground) is an additional 4794 kJ/y (4525 x 10^9 Btu/y)

The principle direct use projects, their resource temperature, and annual energy use, are identified in Table 2, with the largest energy users listed first. The largest industrial process is the use of geothermal fluids to enhance oil recovery from the Williston Basin in Central Wyoming. However, fluctuating oil prices may impact the degree to which it is utilized. Two firms in Nevada are using geothermal fluids to enhance heap leaching operations to extract precious metals. Over 20,000 users in the State of Florida account for the greatest number of heat pump installations, followed by Michigan and

Table 2. Principle Direct Use Systems in the United States

Application	Resource Temperature °C	Resource Temperature °F	Annual Energy Use kJ/y	Annual Energy Use 10^9Btu/y
Industrial				
Enhanced Oil Recovery				
Amoco, WY	93	200	10,000	9480
Heap Leaching				
Round Mountain Gold Corp, NV	85	186	277	263
Pegasus Gold Corp Florida Cary, NV	114	238	42	40
Food Drying				
Geothermal Food Processors, NV	132	270	91	86
Mushroom Growing				
Oregon Trails Mushrooms, OR	113	235	57	54
Heat Pumps (Heating)				
Florida, all of state	24	75	885	839
Michigan, all of state	8	47	375	355
Indiana, all of state	12	54	353	335
Pools/Spas				
Payne's Fountain of Youth RV Park, WY	52	125	691	665
Hot Springs State Park, WY	57	135	504	478
Hunt's Ash Springs, NV	36	97	187	177
Aquaculture				
Hot Creek Hatchery, CA	16	61	212	201
Fish Breeders of Idaho, ID	32	90	184	174
Hyder Valley, AZ	41	105	148	140
Greenhouses				
Troy Hygro, UT	110	230	497	471
Burgett Floral Greenhouses, NM	118	245	69	65
Utah Roses, UT	51	124	47	45
High Country Roses, MT	66	151	35	33
Space Heating				
Peppermill Casino, NV	53	127	66	63
Residences (505 each), Klamath Falls, OR	93	200	46	44
Residences (200 each) Reno, NV	49	120	34	32
Merle West Medical Center, OR	88	191	25	24
District Heating				
Mammoth Lakes, CA	149	300	127	120
Litchfield Correctional Center, CA	77	170	82	78
Boise City, ID (two systems)	77	170	77	73
San Bernadino, CA	59	138	47	45

Indiana. Paynes Fountain of Youth RV Park, and Hot Springs State Park, both in Thermopolis, Wyoming, are the largest pool/spa operations.

Facilities at the Hot Creek Hatchery near Mammoth Lakes, California and the Fish Breeders of Idaho, Buhl, Idaho are the biggest aquaculture sites.

The Mammoth Lakes district heating system, now under construction, is the largest district heating user of energy. This is followed by the Litchfield Correctional Center at Susanville, California. The two systems in Boise, Idaho are third. The Boise City system has recently greatly reduced annual usage by reducing the amount of excess, or waste, geothermal fluid flow through their system.

The largest greenhouse energy user is Troy-Hygro, which is building a 113,000 square meter (28 acre) facility at New Castle, Utah. Second in size is Burgett Floral at Animas, New Mexico.

The Peppermill Casino, Reno, Nevada has the largest space and water heating energy use, followed by New Mexico State University in Las Cruces, New Mexico. Next in size are the 500 individual homes that utilize downhole heat exchangers in Klamath Falls, Oregon.

Data have been gathered on 44 of the 50 United States as of the date of the preparation of this paper. Table 3 provides a summary of the principle states that utilize geothermal energy, and the estimated annual usage of that energy. The principal uses and the range of resource temperatures are also identified.

Table 3: State-by State Summary of Geothermal Energy Use

		Resource Temp. Range		Annual Heating Energy		Heat to Ground[b]	
State	Use[a]	°C	°F	kJ/y	10^9Btu/y	kJ/y	10^9Btu/y
AK	S, G, P	43-67	109-153	54	51		-
AR	HP,S,P	17-59	63-139	77	73	195	185
AZ	A,HP,P,S	17-60	62-140	246	233	10	9
CA	A,DH,P,S,I,G	16-149	61-300	1124	1065	N/A	N/A
CO	A,P,S,DH,G	11-79	52-175	415	393	7	6
FL	HP	22-24	72-75	887	840	2174	2060
GA	HP,S,P	19-31	67-88	26	25	43	41
HI	I	175	347	N/A	N/A	N/A	N/A
ID	A,DH,S,P,G	32-93	90-200	566	536	N/A	N/A
IL	HP	12	54	187	177	151	143
IN	HP	13	55	354	335	286	272
KY	HP	15	59	164	155	150	142
LA	HP	21	69	83	79	258	244
MD	HP	13	57	87	82	60	57
MI	HP	8	47	375	355	148	140
MN	HP	7	45	100	95	30	28
MT	G,DH,S,P,G,I,A	21-83	70-181	133	126	N/A	N/A
NC	HP	17	63	85	80	113	107
ND	HP	6	42	54	51	13	12
NM	G,S,P	45-118	113-245	121	114	N/A	N/A
NV	I,P,S,DH,A,HP	30-132	87-270	890	844	2	2
NY	HP,S	8-52	46-125	47	45	13	12
OH	HP	12	53	240	227	176	167
OR	I,S,DH,P,G,A	12-113	53-235	349	331	1	1
PA	HP	11	52	129	122	98	94
SC	HP	19	67	57	54	109	103
SD	P,HP,DH,S,G,I	8-68	47-155	139	131	17	16
TX	HP,P,S,G,A,	19-52	67-126	143	135	283	269
UT	G,HP,P,A,S	16-110	60-230	743	704	25	24
VA	HP,S,P	15-40	59-104	70	66	46	44
WA	HP,P	13-53	55-128	50	47	25	24
WI	HP	8	46	199	189	69	65
WY	I,P,A	8-93	47-200	11,377	10,784	N/A	N/A
AL,DE, IA,MO, MS,NB, NJ,OK, TN	HP	11-21	52-69	253	240	272	258
				19,824	18,791	4,774	4,525

a. S = space heating; DH = district heating; HP = heat pump; G = greenhouse; I = industrial; A = aquaculture; P = Pools

b. The sum of the capacity of each well plus the compressor energy.

TRENDS AND OBSERVATIONS

The geothermal direct use industry is expected to increase significantly in the use of groundwater heat pumps and vertical earth-coupled systems, and moderately in other sectors. This year, over 10,000 earth-coupled and 8,000 groundwater-source heat pumps will be installed; this is a 50 percent increase over 1987. However, a marked increase in fossil fuel prices could accelerate general direct use of geothermal energy in other areas as well. Current plans for about 26 projects should increase the annual energy use by 1780 kilojoules per year (1690 x 10^9 Btu/y). Most of the gain would be attributed to new district heating projects planned in California (2), Oregon (3), Nevada (2), Idaho, South Dakota, and Colorado. Greenhousing will be a growth contributor in California (2), Colorado, New Mexico, Oregon and South Dakota. Penicillin culturing and the development of other pharmaceuticals will be performed in Casper, Wyoming. About 360,000 lobsters will be raised each year in Carson City, Nevada. Hawaii is investigating the use of geothermal energy for glass forming, silk dying, and wood drying.

In the operation of geothermal direct use systems installed during the late 1970's and early 1980's, asbestos cement pipe continues to be an excellent performer. The combination of an oil-lubricated shaft pump with a hydraulic drive is proving to be the best downhole pump, primarily because it can be maintained by locally available service persons. (Downhole production well pumps have probably been the largest technical failure.) Plate-type heat exchangers have proven to be trouble free, and epoxy joining of fiberglass pipe is also successful.

CONCERNS

With any development, there are concerns. Most geothermal direct use projects have been able to surface discharge spent geothermal fluids in the past. However, especially in areas where multiple users draw fluids from a common aquifer, the drawdown of geothermal fluids may necessitate varying degrees of reservoir analysis and the use of injection wells to maintain aquifer stability. Increasing surface discharge water quality restrictions, such as in California, may also increase the need for injection. The Boise, Idaho, and Klamath Falls, Oregon, and other district heating systems are currently experiencing concerns over aquifer stability.

The resolution of water rights will continue to be a significant issue in the direct use area.

Many of the district heating systems were designed to handle large peak loads which require several years of system growth to develop. Early, relatively low-load operation of the system can be quite unstable due to control valve oversizing. Temporary manual control of these systems has successfully addressed this problem.

Many existing buildings have been retrofit to accommodate geothermal heating. Problems have arisen because the systems are not extracting enough heat from the heating fluids. The resulting poor performance of some retrofits is blamed on the entire geothermal system, which in turn results in customer rejection. This problem appears to be occurring mainly in smaller communities, where the level of expertise needed to install proper retrofits is not normally available.

CONCLUSIONS

The United States Geothermal direct use industry is and will continue to experience a significant growth rate with a qualified infrastructure of developers and users being available to enhance that growth. The largest growth should continue to occur in the use of groundwater source heat pumps, and district heating and greenhousing will add to the expansion of the industry. Development technologies are expanding the use of geothermal energy, and this trend is expected to continue.