Fluid Heat Management
for Direct Geothermal Energy Applications

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ABSTRACT

This paper addresses the problem of utilizing the geothermal fluid as economically as possible in direct applications of geothermal energy. The lower temperature uses are primarily addressed, since these are the only ones likely to make a significant impact in the eastern United States.

I. Capital Investment Utilization of Geothermal Facilities

The two categories of direct heat uses that require different approaches on geothermal fluid management are:

1. Process heat for industries that that operate full-time (or nearly full-time) all year around.
2. Space heating, which is used only part of the year.

There is a major difference between these two categories of applications. The first nearly fully utilizes an expensive capital system. The second poorly utilizes an expensive investment. The conclusion is to concentrate on the process heat applications, and leave the space heating to the low capital cost methods. However, Table 1 shows that space heating is a far greater energy consumer than industrial process heating below 300°F. Futhermore, Table II breaks down the temperature range for utilization temperature at the end use point. One therefore concludes: If geothermal energy is going to make a significant contribution to the nation's energy needs, then it must be applied to the low utilization markets.

II. Better Utilization of Geothermal/ Investment for Space Heating

Most cities and towns away from the steadying climate effects of the sea coasts have extreme variations in temperature, not just season-to-season but day-to-day. Figure 1 shows the temperature frequency histogram for Boise, Idaho, typical of a northern U.S. climate. The degree F-days of heating average about 5700. The trend of the plot is striking, showing that temperatures below 20°F are rare. Yet the design outdoor temperature for Boise heating systems is 3°F (ASHRAE), and it has been common to

TABLE I

USA ENERGY USE vs TEMPERATURE

USE	Temperature Of Use (F°)	Amount (Quad, or 10^{15} Btu)	% of Total
Total Annual Energy Use (1978)	--	75	100%
Space Conditioning and Water Heating	Below 165° [a]	17	23
Industrial Uses-- primarily food processing	165° to 210°	2	3
Industrial Uses	210° to 300°	5	6
Air Conditioning	Electric Today [b]	2	3

[a] Space heating can be accomplished with source temperatures as low as 120°F. Water heating for domestic use with temperatures as low as 140°F. Note: some space heating with steam is at higher temperature.

[b] Air conditioning could be supplied by solar or geothermal heat sources as cool as 180°F.

TABLE II

USA-Temperature of Use vs Amount of Use

Temperature	167°F	200°F	250°F	300°F	400°F
% of Energy Use at or Below This Temperature	20%	23%	27%	32%	42%

design to as low as -10°F.

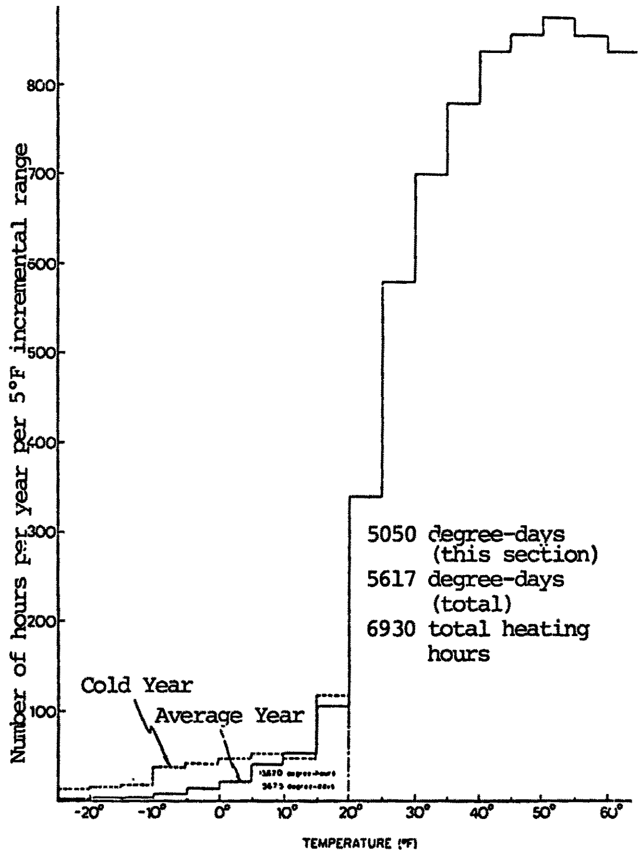

Fig. 1

Boise, Idaho - Average Annual Temperature Histogram for Heating

As an example of better utilization of the expensive capital investment of the geothermal system, if the maximum geothermal fluid supply to a building in Boise could only maintain indoor comfort at temperatures as low as 28°F, the heating system would have a shortfall for the year of only 6% of the actual total requirements. Yet at 28°F, the geothermal fluid supply can serve twice as many buildings as one designed to serve buildings down to -10°F. Compared to a 3°F design, the geothermal system is utilized 170% more effectively. The result is reducing the costs of the geothermal energy supplied by these factors. For instance, if designed to -10°F, this system in Boise only is used 22% of its full potential. Whereas if designed for 28°F, the utilization factor is 45%.

But what happens to the 6% shortfall? Auserity is one possibility, but is not likely to be acceptable in our affluent society.

The use of a peaking system operated from a storable fuel is an appropriate solution. Even if boiler heat-up raises the effective use of the 6% shortfall to 8% and even if that fuel is expensive, this solution is far better than half of an expensive capital investment sitting idle 94% of the time.

III. Well Sizes and Pumps

Most geothermal wells for direct applications should be pumped even if they are naturally free flowing. Pump costs will generally be only 10 to 25% the cost of the well, yet allow the fluid level to be drawn down to low levels as a result of significantly higher production flow rates.

Again the problem arises of the cost of pumping, even though this is generally a very small fraction of the energy produced. Space heating needs vary hourly. It is wasteful for a pump to be pumping much more fluid than is actually needed. If flow control valves are used, the pump will still be consumming electricity. Variable speed pumps are a partial solution, but the efficiency of the variable speed motors is poor away from the peak performance area of the curve.

Hence it is better to design a system of several wells rather than a single well. This not only gives easier pump staging, but offers effective redundancy to cope with breakdowns. Both from consideration concerning keeping the cost of the initial exploratory well low, and for reservoir performance effects, several wells is a better choice than a single large well.

IV. Heat Exchangers

If the fluid is poor chemically (such as greater than 10,000 ppm. dissolved solids), heat exhange to a pure, noncorrosive, non-scaling fluid for the main heating system is probably a necessity. Tube-in-shell heat exchangers of titanium, brass, or stainless steel will generally be needed.

For the purer fluids, the quesion of heat exchange should be decided on a case-by-case basis. H_2S is very corrosive to copper tubing, common in hot water air heaters and blowers. Yet, there are some heating systems containing significant H_2S that, fortuitously, have operated for many years with copper-tubed air heaters. These systems had much copper piping upstream, this piping acting as a getter for the H_2S and thereby protecting the expensive heaters. Replacing straight runs of copper pipe periodically is less expensive than building a secondary system.

V. Chemical Problems of Deposition and Corrosion

Practically all geothermal waters have no free oxygen, thus are nominally non-corrosive if oxygen is not allowed to enter. Conversely, from carbonate rocks, the geothermal waters will have a high concentration of bicarbonate ions. These will be lost by depressurization and release of the CO_2 gas. The effect will be precipitation of calcium carbonate. These two reasons make it necessary to maintain pressure on the geothermal fluid from the bottom of the production well to the final point of discharge, thus avoiding the most serious and obvious corrosion and deposition possibilities.

Silica, originally in crystalline state, is not likely to be a problem in geothermal systems in the east. For instance, for 300°F geothermal waters, the amount of crystalline silica will remain in solution in the amorphous phase down to 90°F.

VI. The Incentive for Best Utilization.

As much heat as possible, within economic and technical feasibility, should be extracted from the goethermal water before it is discharged. Consequently, it is preferable to charge the user by the easily measured quantity of water rather than by Btu's utilized. The user thus has the incentive to make the maximum use of the heat content in the water. This approach will allow the user to make the economic decisions concerning how large the air-handling heat exchanger will be, which in turn determines how much heat can be extracted from the geothermal water.

VII. Differences Between Eastern and Western USA in the Fluid Management Decisions.

The above concepts in fluid management system design and operation will apply to geothermal direct heat applications anywhere. However, the resources in the east will generally be at greater depths, requiring much greater fraction of the total investment in the energy supply system. Hence, the incentive, in the East will be greater to "make the most" of the geothermal fluid brought to surface, and to bring as much to the surface as possible by effective use of pumps. The trend in the East, therefore, will be to spend more on surface equipment so as to achieve the better utilization of the available fluid. These trends will result in projects that have larger minimum sizes, for economical construction and operation. Fortunately, the East has the far higher concentrations of population that can utilize the larger project sizes.