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POTENTIAL UTILIZATION OF GEOTHERMAL ENERGY FOR SPACE AND PROCESS HEATING IN ELEVEN WESTERN STATES

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INTRODUCTION

A number of factors will make direct thermal (nonelectrical) applications have a significant potential in the proper use of the bulk of geothermal resources. Some of these factors are: (1) the abundance of low- to medium-temperature (194° to 300°F) resources, which are estimated to be nearly four times larger than those at higher temperatures; (2) a very large portion of the basic energy needs of an industrialized nation is for heating at low to medium temperatures; and (3) low- to medium-temperature heating needs are difficult to meet efficiently from electricity or fossil fuels, as indicated by the poor thermodynamic performances of most systems supplying present needs.

U.S. CONSUMPTION OF ENERGY IN THE LOW- TO MEDIUM-TEMPERATURE RANGES

The overall U.S. potential for direct applications of geothermal resources below a temperature of 300°F is estimated at 34.3×10^{15} Btu, or 47 percent of total U.S. energy use, and is more than 60 percent of the energy consumed for purposes other than transportation. The categories of U.S. energy consumption are shown in Table 1, based on 1974 U.S. Bureau of Mines data. (ERDA, 1976)

Table 1. U.S. Consumption of Energy (1974)

	Energy (10^{15} Btu)	Percentage of total
Residential and commercial space heating	13.9	19.1
Industrial	20.4	27.9
Transportation	18.4	25.3
Utility electricity generation	20.0	27.4
Miscellaneous	0.2	0.3
TOTAL	72.9	100.0

Space heating at temperatures below 212°F is by far the largest single energy use at temperatures suitable for direct geothermal applications, representing almost 50 percent of the total for temperatures below 300°F as shown in Figure 1. In addition, residential and commercial water heating represent a substantial geothermal potential--2.4×10^{15} Btu, or 10 percent of the total for temperatures at 212°F or below.

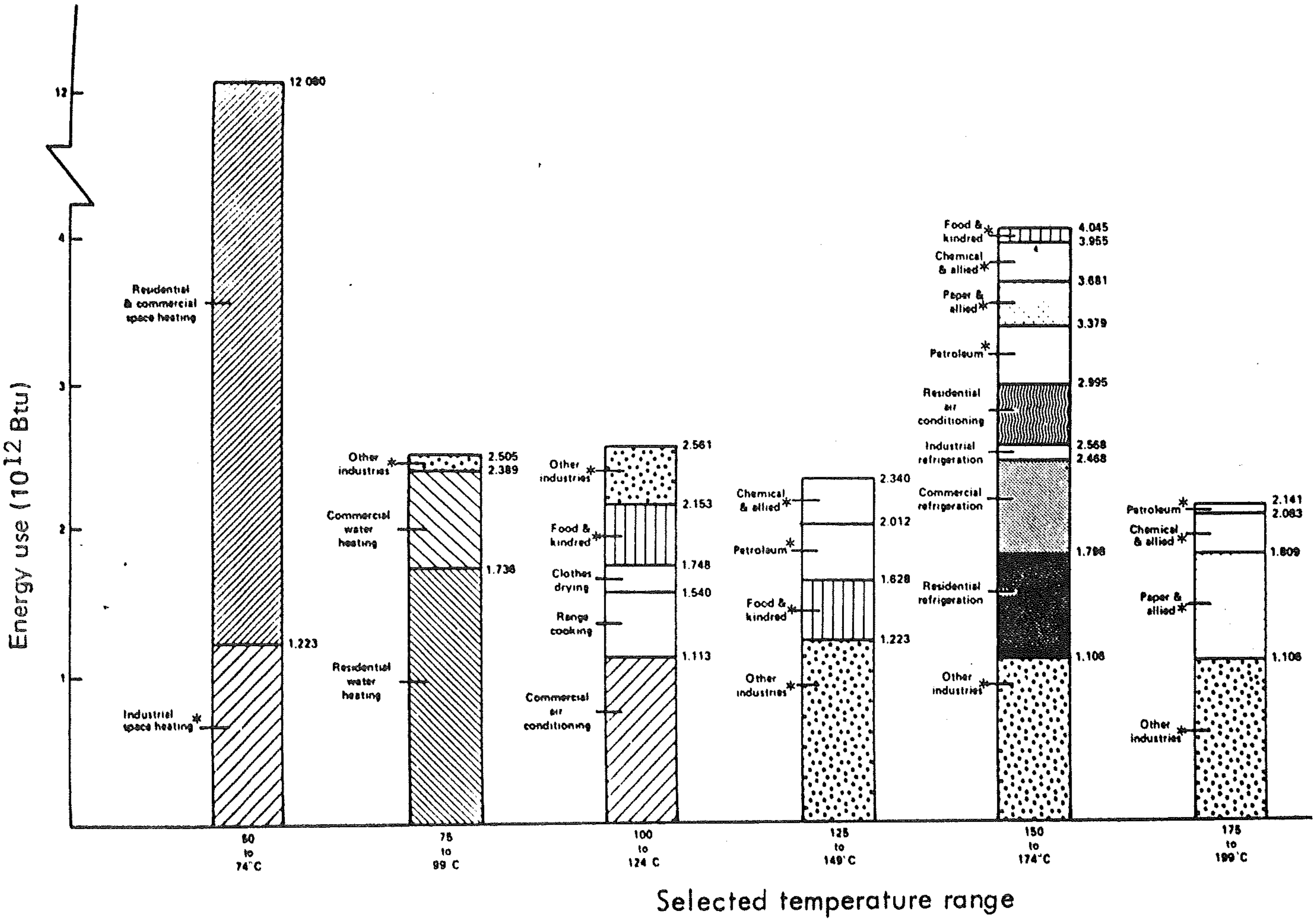

Figure 1. Estimated heating energy use in selected 25°C temperature ranges. (Source: Reistad, 1975)

Large industrial processes that could use geothermal energy directly include the chemical, paper and allied products, food, and petroleum industries, which uses an estimated 4.2 x 10^{15} Btu's annually; however, competition with waste steam from electricity generation will be stiff. (Reistad, 1975)

An example of a major food processing industry seriously considering conversion to geothermal energy is Ore-Ida Foods, Inc., located at Ontario, Oregon, which processes about one million pounds of frozen potato products per day. The company's processes to be supplied by geothermal energy are distinguished in Table 2 by their function and temperature and represent 55 percent of the plant's total annual energy (.58 x 10^{12} Btu/yr) consumption.

Table 2. Ore-Ida Foods, Inc. Processes
to be Supplied by Geothermal Energy

Function	Heat rate (million Btu/hr)	Temperature In (°F)	Temperature Out (°F)
Peeling	4.12	260	200
Peeling	5.63	200	150
Peeling	14.6	150	100
Hot blanch	16.52	200	100
Warm blanch	8.92	150	100
Water heating	2.62	150	50
Plant heat	11.00	150	100

The geothermal fluid will pass through plate-type heat exchangers, to avoid possible contamination of the product by the geothermal fluid.

Energy requirements for high-temperature (200°F or more) processes are satisfied by dropping the geothermal fluid temperature from 300° to 190°F. The lower-temperature processes are then supplied partially by this cooled-off geothermal fluid and partially by fresh geothermal fluid as shown in Figure 2.

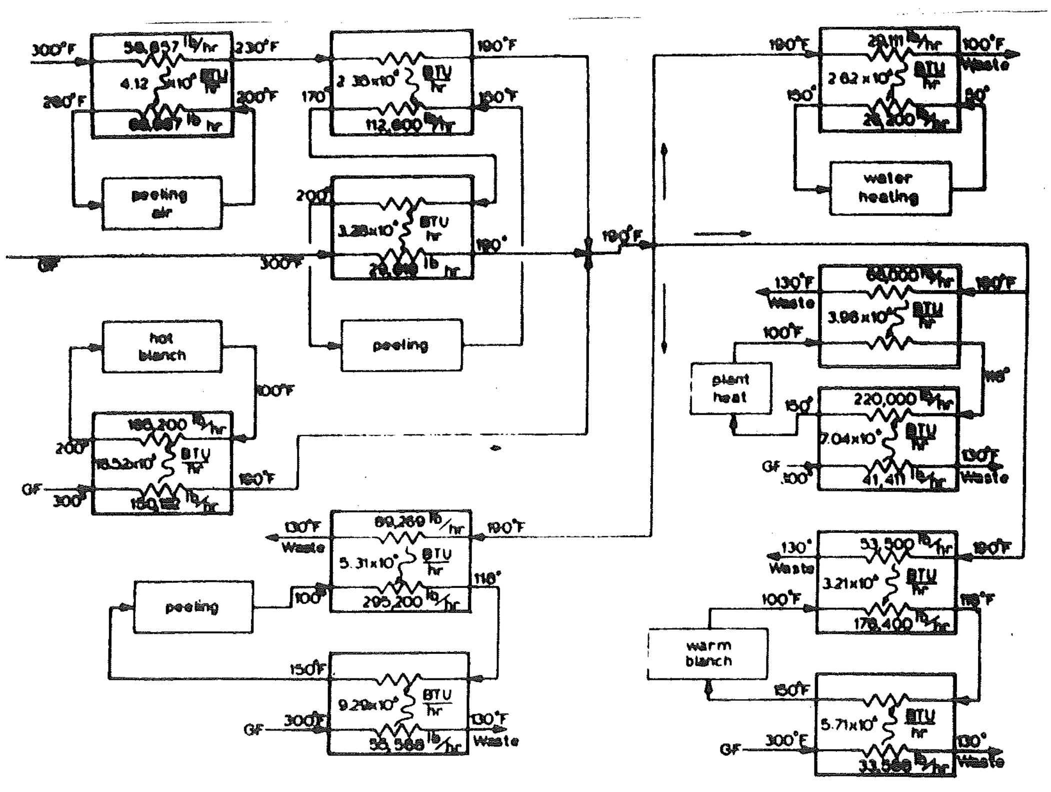

Figure 2. Ore-Ida Foods, Inc.
Flow diagram for geothermal conversion

An anticipated temperature drop of 170°F (57 percent efficiency) for the geothermal fluid will supply 63.4 million Btu/hr needed to process roughly 370,000 lb/hr. This should be readily available from two wells, with adequate margin for load variation or delivery rate fluctuation.

From the economic analysis for Ore-Ida Foods, Inc., a 30 percent return on investment (ROI), or 3.6-year after-tax payback was calculated for a 15-year project life. The total after-tax dollars available at a 20 percent ROI for intangible drilling costs is $2.9 million. Considering the after-tax cost of drilling an 8,000-foot well, the company could afford to drill eight wells and one injection well. In other words, with a geothermal resource confidence level as low as 25 percent, Ore-Ida Foods could still realize a 20 percent ROI.

POTENTIAL GEOTHERMAL ENERGY SUPPLY

Unlike Ore-Ida Foods, Inc., most of the nonelectric use of geothermal energy will occur some distance from the wellhead. In order to determine a rough estimate of the potential geothermal supply to identified users in 11 western states, the 224 USGS identified hot-water convection systems with temperatures from 194° to 300°F were used as a resource base (Figure 3). The USGS estimates the undiscovered resource in this temperature range contains three times the energy of the identified systems. (White, 1975)

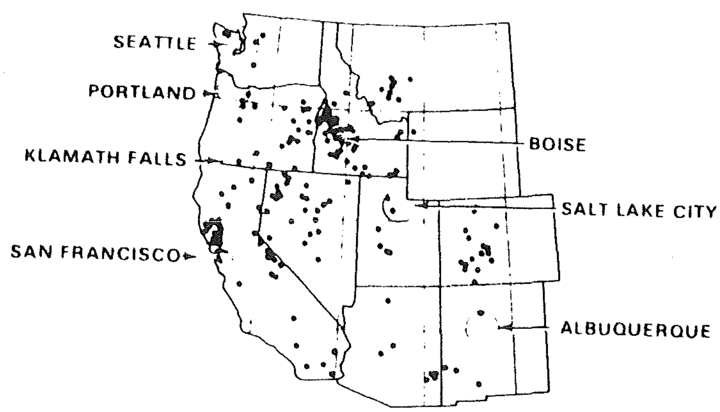

Figure 3. Location of geothermal resources in the 194° to 300°F range.

Supply curves for geothermal space and process heating at the point of delivery and several distances from the wellhead have been developed by Battelle Northwest Laboratories (Bloomster, 1977). The supply curves are the sum of two costs--the energy production and transmission costs--and they represent the cost of delivering heat to a district of process heating center (Figures 4 and 5).

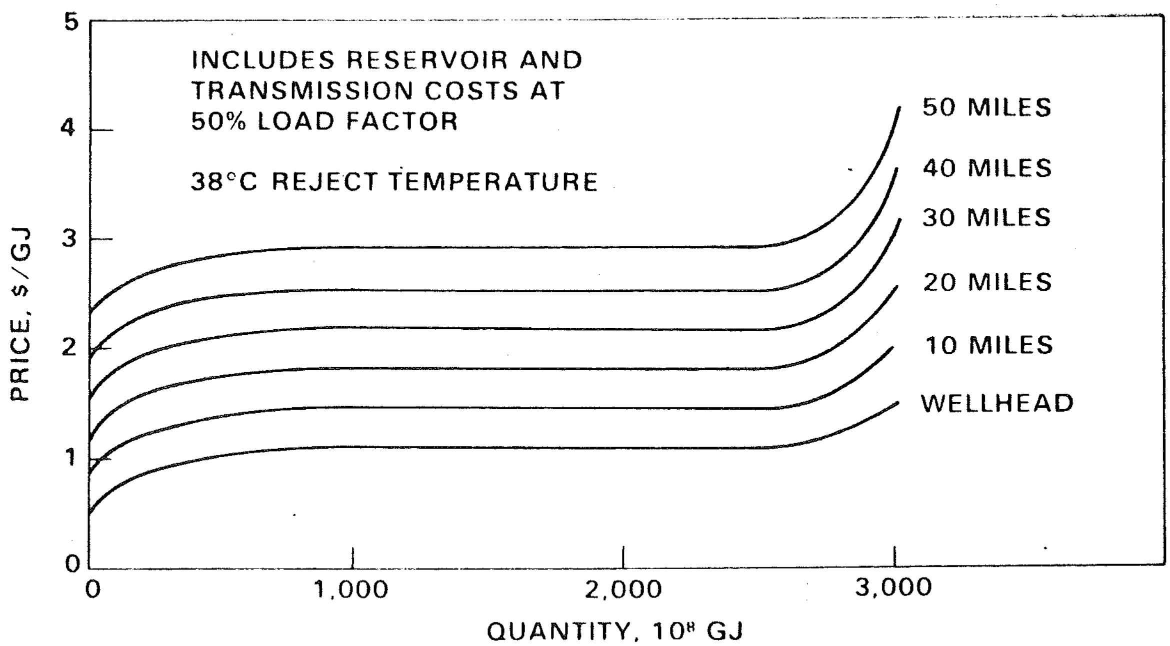

Figure 4. Supply curve at the point of delivery for geothermal space heating. (Source: Bloomstir, 1977)

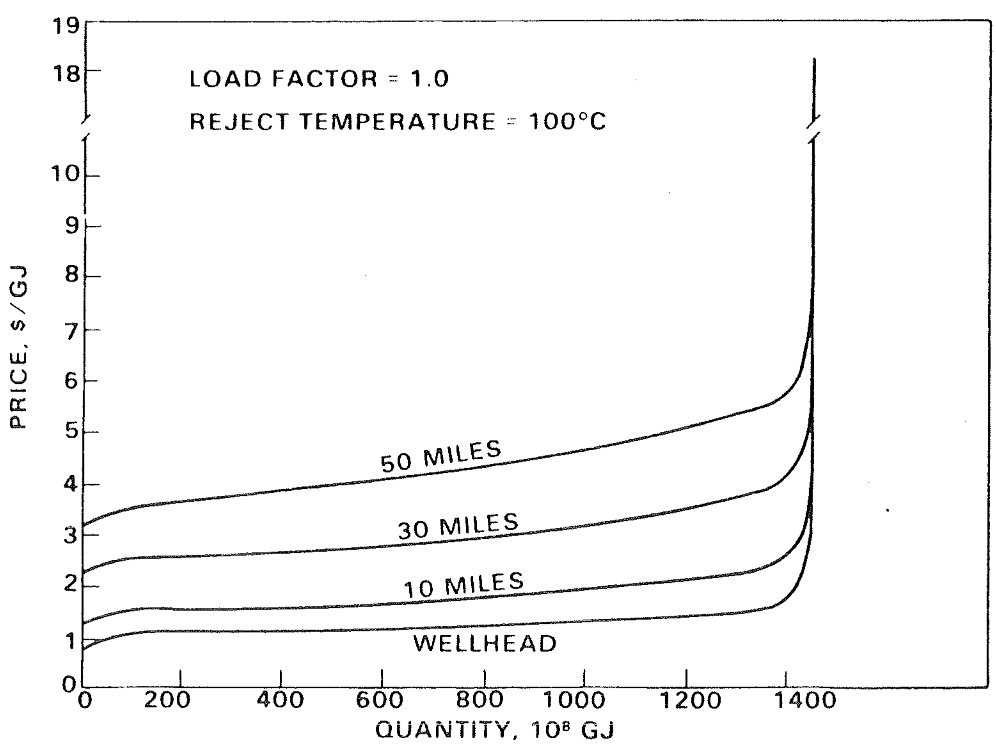

Figure 5. Supply curve for geothermal process heating. (Source: Bloomstir, 1977)

For space heating, only the heat above 100°F was considered with a 50 percent load factor. The supply curve for geothermal process heating considers a load factor of 100 percent and reject temperature of 212°F.

The high reject temperature for process heating offers the opportunity for other uses of the reject heat. If this waste heat is used beneficially (by cascading), then process heating costs might be lowered through sharing the production and transmission costs among end users.

Compared to the $2/GJ to $3/GJ estimated cost of providing process heat from coal, geothermal energy for industrial process heating should be supplied competitively from the 250° to 300°F hydrothermal resources out to 30 miles from the wellhead.

Although no technological breakthroughs are required in the utilization of geothermal energy for these direct thermal applications, technological advances are needed to reduce costs and increase the distance over which geothermal energy can be competitive. Significant cost reductions would be achieved by reducing well-drilling costs, stimulating well flow rates, increasing productivity in pipeline construction, developing low-cost pipe materials, defining and identifying the resource, and reducing fluid disposal costs.

POTENTIAL DEMAND OF GEOTHERMAL ENERGY

The potential demand for geothermal space and process heating surrounding the 224 hot-water convection systems identified by the USGS in the 11 western states is large. Over 10 percent of the U.S. population resides within 40 miles of the resources (Table 3). This space heating demand would require about 5 percent of the potential annual energy production from the identified 194° to 300°F hot-water convection systems.

Table 3. Potential Existing Demand for Space and Process Heating

Distance from Resource	Total population	District heat demand (10^{12} Btu)	Process heat demand (10^{12} Btu)
0 - 5	120,000	1.9	2.8
5 - 10	330,000	5.7	7.6
10 - 20	3,950,000	74.9	94.8
20 - 30	6,070,000	86.3	146.0
30 - 40	14,210,000	180.1	342.2
40 - 50	9,670,000	129.9	233.2
	34,350,000	478.8	826.6

Although the demand for geothermal district heating is very large, 40 percent of the demand probably cannot be met competitively because of the low population density and since much of this demand occurs in regions where the heating degree days are low, leading to low load factors for district heating. However, with the development of low-temperature absorption air-conditioning units, this energy could also be used for cooling.

Although rough estimates were used in this paper to present a picture of the potential use of geothermal energy for space and process heating, this potential is obviously large and relatively short-term in development.

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