MAMMOTH GEOTHERMAL DISTRICT HEATING SYSTEM

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BACKGROUND

Southern California Edison (SCE) has been interested in geothermal prospects in the Long Valley area of California for a number of years; Long Valley appears to be a large reserve containing perhaps 30% of the known geothermal reserves in California. It apparently contains low total dissolved solids (TDS) brines, temperatures in the order of 350°F, and part of Long Valley lies within Edison's service territory, so any power generated there could be tied directly into Edison's net.

In 1971, SCE, through an affiliate company, entered into a joint exploration venture with Getty Oil. Two wells were drilled on the shores of Mono Lake in Long Valley, both of which turned out to be unsuccessful.

South of Mono Lake, Magma Power Company owns in fee 90 acres of land at the Casa Diablo Hot Springs area near Mammoth Mountain. Nine wells have been drilled on the site, and a number of well flow and heat exchanger tests were performed during the period from 1959 to 1975.

In 1974, a preliminary design was completed for a 15-MW geothermal binary cycle power plant to be installed at Casa Diablo. It was subsequently determined that there was insufficient resource potential on the privately owned land to support a major generating facility there. This project is being delayed until geothermal leases on the surrounding federal lands become available.

In August 1976, ERDA awarded a contract to the Ben Holt Company, with SCE and Magma Power Company as participants, to perform a 12-month study to assess the technical environmental, and economic feasibility of a geothermal district heating system serving the village at Mammoth Lakes and utilizing the Casa Diablo Resource. This study is now about 75% complete. The majority of the technical and economic work summarized here has been performed by the Ben Holt Company, under the direction of W. C. Racine.

INTRODUCTION

Mammoth Lakes Village is located on the eastern slope of the Sierra Nevada Mountains about 483 km (300 miles) north of Los Angeles, California (Figure 1). The Village is a winter skiing and summer fishing resort with a permanent population of about 3000. On peak winter weekends, the population of the Village has reached 18,000. The houses, condominiums, motels, and commercial buildings in the Village use electric energy for most of their space and water heating demands. The purpose of the work described in this paper is to determine if a geothermal district heating system can be utilized as an alternate means of providing heating.

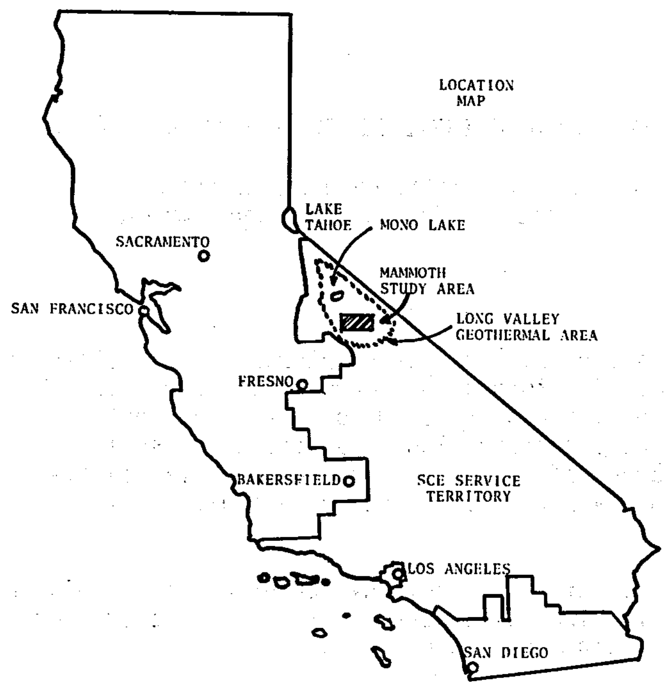

Figure 1

The study is divided into six tasks as follows:

1. Literature Search
2. Load Surveys
3. Reservoir Analysis
4. Heating Unit Selection and Retrofit Study
5. System Design and Cost Estimate
6. Environmental Evaluation

The results of work completed to date on tasks 2, 3, 5, and 6 will be summarized here.

LOAD SURVEYS

SCE performed a number of load surveys in order to establish the characteristics of heating loads in Mammoth Lakes Village. The data sought from the surveys include the peak heating load, heating load factor, monthly heating energy consumption, potential market for retrofit of existing facilities to geothermal heating, and a geographic distribution of connected load within the town. The surveys and source data included a door-to-door survey of 122 facilities, a review and analysis of SCE's billing records, SCE's local substation load demand charts, the Mono County Plan, utility association load studies and data from a metering program initiated under this study.

Results of the survey work indicate that the Village is characterized as tabulated below.

- 2800 Condominium units in 60 developments
- 1200 Motel/Lodge rooms in 40 developments
- 1200 Single family homes
- 24 Restaurants
- 150 Other commercial/institutional facilities

The total connected heating load is comprised of 84% electric resistance type and 16% liquid petroleum gas type units. In addition, of the total connected space heating load, only 14% is of the forced air type, which is the least costly type of unit to convert to geothermal district heating. The monthly energy consumption varies by a factor of 12:1 between the winter and summer months (Figure 2). Based on projections of total load growth and potential market penetration of the geothermal system, a geothermal system demand vs. time curve was developed (Figure 3).

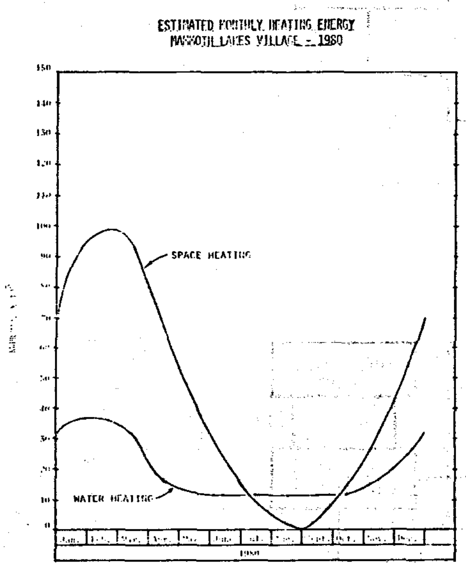

Figure 2

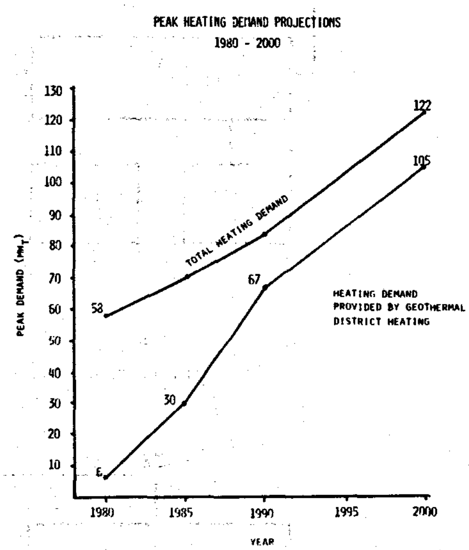

Figure 3

RESERVOIR ANALYSIS

Information obtained from the United States Geological Survey (USGS) and data from flow tests on seven of the nine wells drilled indicate that the Casa Diablo geothermal area has the capacity to provide the space and water heating needs of the town of Mammoth Lakes. USGS estimates suggest the potential of a 200-year supply of heating energy beneath the 90-acre Casa Diablo site. Wellhead temperatures of 166°C (330°F) to 171°C (340°F) and flow rates of 38-63 kg/s (300,000 to 500,000 lb/hr) per well have been measured during short-term testing.

SYSTEM DESIGN AND COST ESTIMATE

Based upon the heating demand characteristics and expected geothermal water temperatures and flow rates determined above, two alternate geothermal district heating system configurations were defined (Figure 4). In Alternate 1, a low temperature (LT) system, fresh water at about 93°C (200°F) is stored in tanks at atmospheric pressure and flows through hydronic space and water heaters in buildings upon demand. Alternate 2 is a high temperature (HT) closed loop system in which 149°C (300°F) fresh water is supplied to the heat exchangers of closed hydronic heating systems in each building being served. The design parameters, capital costs, and annual costs of the two alternatives are indicated on Tables 1, 2, and 3, respectively.

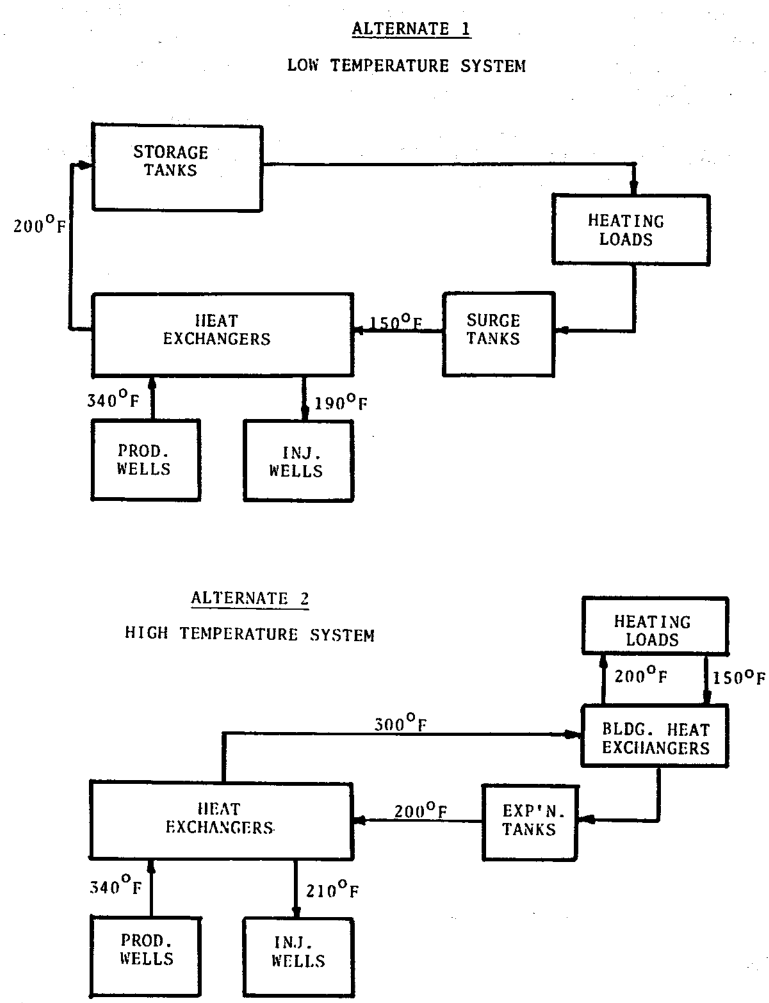

Figure 4

Table 1
DESIGN PARAMETERS

	LT System	HT System
Main Supply Pipeline Diameters	.4 m (16 in)	.3 m (12 in)
Hot Water Peak Flow Rate	.37 m^3/s (5900 gpm)	.24 m^3/s (3800 gpm)
Geothermal/Fresh Water Heat Exchanger Surface Area	1672 m^2 (18,000 sq ft)	5017 m^2 (54,000 sq ft)
Geothermal Water Peak Flow Rate	.18 m^3/s (2900 gpm)	.25 m^3/s 3900 gpm
Number of Building Heat Exchangers Required	None	

Table 2
CAPITAL COST COMPARISON
(Thousand Dollars)

	LT System	HT System
Piping Mains	1800	Base
Wells	Base	200
Well Pumps	Base	300
Heat Exchangers	Base	700
Tanks	Base	1200
Circulating Pumps	200	Base
Building Heating Systems	Base	3600
TOTAL	Base	4000

Table 3
ANNUAL COST COMPARISON
(Thousand Dollars/Year)

	LT System	HT System
Carrying Charges on Capital	Base	800
Operating Costs		
Labor and Material	Base	40
Electric Power	120	Base
TOTAL	Base	720

Table 3 clearly shows that Alternate 1, the low temperature geothermal district heating system, offers superior economics for the case of Mammoth Lakes Village.

ENVIRONMENTAL EVALUATION

SCE has completed a preliminary assessment of the environmental feasibility of the geothermal district heating system. The areas specifically addressed included the biological setting, rare and endangered species of vegetation and wildlife, aesthetics, population, transportation, and archaeology. The environmental impacts of the heating plant, the underground transmission and distribution piping and the storage tanks were considered. The scope of the preliminary assessment did not include air quality, water quality, land use, geology and seismicity, or climate.

The data sources for the study include two field trips to the site by representatives of SCE's Environmental Planning Department, the Final Environmental Impact Statement for the Geothermal Leasing Programs by the Department of the Interior, the Mono County Plan Draft Environmental Impact Report, and environmental reports prepared for an earlier proposed geothermal power plant at Casa Diablo, and for a SCE transmission line.

In general, there have been no potential adverse environmental impacts identified to date of sufficient consequence to preclude the construction and operation of the proposed district heating system.

REMAINING/FOLLOW-ON WORK

The completion of the feasibility study will include optimization of the low temperature system configuration, completion of the system preliminary design, and comparison of geothermal heating costs with alternatives.

In addition to the ERDA-funded feasibility study, two other programs at Mammoth are underway.

SCE has contracted the Ben Holt Company to look into the technology and economics of a system combining power generation, using a binary cycle, with a district heating system as a bottoming cycle.

The State Energy Commission recently awarded a contract to the same team of Holt/SCE/Magma to design, construct, and operate a geothermal district heating pilot project at the Casa Diablo site. This project will include installation of a well pump on existing well, a heat exchanger plant, and a heating loop serving hydronic heaters in a hardware store and a lumber shed located on the Magma property.

At the conclusion of these programs, the results will be reviewed by SCE to determine how such a district heating system might fit into SCE's service system.