ECONOMICS OF GEOTHERMAL SPACE/WATER HEATING IN MAMMOTH LAKES, CALIFORNIA

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INTRODUCTION

Mammoth Lakes Village is a winter and summer recreational resort located in the eastern Sierra Nevada Mountains of California at an elevation of 8,000 feet. About eighty-five percent of space and water heating demands for up to 17,000 Village visitors are now provided by electric resistance heating. Utilization of such a highly refined energy resource as electrical energy for heating suggests that alternative energy sources be examined.

Magma Energy, Inc. owns a geothermal resource on a 90 acre parcel at Casa Diablo Hot Springs, about three miles east of Mammoth. Eight geothermal wells were drilled on this property in the years 1959 to 1962. The wells have produced fluid with temperatures in excess of 340°F.

This report presents the results of a one-year study to determine the technical, economic and environmental feasibility of utilizing the Casa Diablo geothermal resource for district heating in Mammoth Lakes Village. The concept studied was to heat a fresh water loop with geothermal brine, circulate the fresh water to the Village where it would provide space and water heating energy via hydronic heaters located in individual buildings, and return the fresh water to the geothermal area for reheating and reuse.

The Ben Holt Co. was the prime contractor for this study. Holt was assisted by Southern California Edison Company (SCE), Ayres Associates (Ayres) and Magma Energy, Inc. (Magma).

SUMMARY

Using data from industry studies, and their internal records, SCE estimated the electric space and water heating demand and energy use for Mammoth Lakes Village in the year 1980. The projected 1980 peak demand for electric space heating is 41 MWe, and for water heating is 8 MWe. Estimated electrical energy use in 1980 for space and water heating are 53 million kwh and 24 million kwh respectively.

In order to validate the data used to estimate 1980 electric heating demands and energy use, SCE installed metering equipment on space and water heaters in eleven buildings within the Village. The metering equipment provided data to determine the percentage of total electric energy consumption attributable to heating, which in turn provided an indication of total heating energy consumption in the Village. Results of the metering work confirmed the above energy and demand estimates.

A survey was undertaken to determine the numbers and types of space and water heating units currently in use in the Village. It was found that approximately 88 percent of the space heating capacity and 74 percent of the water heating capacity depends upon electric resistance heating. The remaining capacity is almost exclusively fueled by Liquid Petroleum Gas (LPG). An estimated 84 percent of all space and water heating load in the Village uses electrical energy.

The 1980 Village peak demands for all space and water heating were estimated using the above survey results to be 47 MWt and 11 MWt respectively. Estimates of growth in visitor population for Mammoth were used to estimate the growth in heating demand through the year 2000. The heating demand was projected to grow from 58 MWt in 1980 to 84 MWt in 1990 and to its ultimate demand of 122 MWt in 2000.

An analysis of the Casa Diablo geothermal reservoir was completed. The analysis was based on results of geothermal well testing in the 1960's and assessments by the U. S. Geological Survey of the heat storage and recoverable energy in the Long Valley area. The reservoir analysis concluded that the Casa Diablo geothermal area has the capacity to provide for 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. Well and heat exchanger testing have provided flow and temperature data for a number of the existing Casa Diablo Wells. Wellhead temperatures of 330°F to 340°F and flow rates of 300,000 lb/hr to 500,000 lb/hr per well have been measured during short-term testing. These temperatures and flows are well in excess of peak space and water heating demand for the entire town of Mammoth Lakes.

While the USGS estimates and flow test results are encouraging, they are by no means conclusive as to the Casa Diablo geothermal area's capacity or longevity. Additional long-term reservoir data need to be provided before a large scale district heating facility can be built on the site.

Magma intends to drill and test a deep production well at Casa Diablo early in 1978. The reservoir information gained as a result of this deep well and associated testing should provide sufficient information for going ahead with a large district heating installation on the site.

In order to implement geothermal district heating in the Village, the electric and LPG heating systems in existing buildings must be retrofit to hydronic heating and new building construction should include hydronic heating. Rough designs and cost estimates were prepared for installing hydronic heating systems in buildings considered typical of existing and new construction in the Village. The mechanical engineering firm of Ayres Associates was employed to prepare the designs and cost estimates for hydronic systems using water at either 200°F supply temperature (low-temperature system) or 300°F supply temperature (high-temperature system). Ayres also prepared cost estimates for installing electric and LPG heating systems in new buildings.

Building hydronic heating systems using a high-temperature district heating loop were shown to be 7 to 78 percent more costly than hydronic heating using a low-temperature district heating system, depending upon the type and size of building under consideration. The main contributor to the increased cost of high-temperature hydronic heating is the heat exchanger required in each customer's building. The low-temperature systems do not require building heat exchangers as the district heating water can be used directly in hydronic heaters located within each building.

Installed cost estimates for LPG and electric heating systems in new buildings were consistantly lower than the cost of installing hydronic systems in the same buildings.

Based upon Village heating demand characteristics and information on the Casa Diablo reservoir, conceptual designs were prepared for alternate high- and low-temperature district heating systems to supply a 52 MWt peak heating demand. Differential capital and annual cost estimates were prepared for each system configuration, and the results were compared. The capital and annual costs of district heating using a low-temperature loop were estimated to be $4 million and $700,000 per year less than using a high-temperature system. Therefore, subsequent design work was limited to the less costly low-temperature district heating system.

A preliminary design and capital cost estimate were prepared for a low-temperature geothermal district heating system to serve the Village. Main components of the system design are pumped geothermal wells, geothermal brine/fresh water heat exchangers, fresh water circulation and booster pumps, hot water storage tanks, and underground hot water piping. The estimated capital cost for the system in 1977 price level is $14.6 million. Approximately 62 percent of the capital cost involves the cost of purchasing and installing the 280,000 feet of preinsulated hot water distribution and return piping necessary to provide district heating service in the Village.

The geothermal district heating system capital cost estimate was compared with cost estimates for new electric power plants which could be used to provide heating energy as an alternate to district heating. The district heating system can be installed for approximately 80 percent of the cost of a combined cycle electric power plant, and 45 to 50 percent of the cost of a coal or nuclear power plant.

Annual costs for heating typical buildings in the Village with geothermal district heating were compared with the costs to heat the same buildings with LPG or electricity. The annual heating costs using geothermal district heating are higher than with conventional energy sources when the system is first installed. However, after a maximum of six years of operation, an investor owned district heating system can provide less costly heating for all typical buildings investigated. If the district heating system is owned by a nonprofit organization, its costs are less than LPG or electric heating after three years. The estimated cost of energy delivered to a typical customer from the district heating system in 1977 price level is 4.3¢/kwh(t) with an investor owned system, and 2.9¢/kwh(t) with nonprofit system ownership.

The economics of district heating may be improved further through the use of co-generation. In this concept, geothermal brine provides heat to an electric power generation cycle before being used to provide heat for the district heating system. Additional improvements in district heating system economics may also be realized by the following cost optimization of the district heating system design, participation by DOE in the first implementation phase of the system, and exploitation of a geothermal resource in closer proximity to Mammoth should one exist.

SCE prepared a preliminary environmental assessment of constructing and operating the geothermal district heating system. The assessment addressed environmental impacts in the categories of biology, archaeology, population, transportation and aesthetics. No potential adverse environmental impacts could be identified of sufficient consequence to preclude construction and operation of the system.

Two models were designed, built and shipped to DOE-Washington which illustrate the use of geothermal energy. One model illustrated a geothermal district heating system for Mammoth, and the other represented a geothermal-electric power plant.

A phased program leading to full scale utilization of geothermal energy for district heating in the Village was outlined. If the program is implemented, district heating service can be operational in a portion of the Village by the winter of 1979-1980, and a 52 MWt peak demand could be served by 1988.

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