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GEOTHERMAL DOMESTIC WATER HEATING AT WARM SPRINGS STATE HOSPITAL IN MONTANA

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ABSTRACT

We are presenting the background and necessary steps that were followed in developing a demonstration geothermal project at the Warm Springs State Hospital in Warm Springs, Montana. This Department of Energy sponsored program, under Cooperative Agreement No. DE-FC07-78ET-27055, was initiated to encourage the development of similar geothermal resources and to utilize the available geothermal energy to replace the natural gas utility requirements of the facility.

INTRODUCTION

Initial work involved obtaining and analyzing the components of the energy distribution system at Warm Springs State Hospital to gather pertinent data on the energy demand of the facility. Degree days and ambient temperature calculations were made to determine building heating requirements. Analysis of the central system plant loads were made to confirm the building heating needs and to substantiate the domestic hot water demand cycles during the nominal 12 hour day.

Recommendations from the preliminary work were to supply the domestic hot water requirement of 30,000 gallons per day (885,000 BTUH) and peak space heating requirements for the Warren Building, main hospital building, (456,000 BTUH) and the Food Service Building (1,943,000 BTUH) with the geothermal resources. A proposal for a production well, reinjection well, and the necessary conversion components was submitted to the Department of Energy Program Opportunity Notice for Field Experiments for Direct Uses of Geothermal Energy. That proposal was approved by the DOE and the project was underway.

ENVIRONMENTAL REPORT AND LEGAL/STATUTORY REVIEW

An environmental report was prepared to determine any adverse environmental or socioeconomic impacts resulting from the demonstration project. The report indicated that very little negative environmental impact would result from the development and demonstration of the geothermal resource. There were also no long-term effects in the social or economic environments anticipated.

A review of the permit requirements substantiate that well drilling permits and production well permits were required. Initial design and environmental considerations provided an option to discharge the spent geothermal water to a wetlands area for game habitat. No permit was required for discharge of spent geothermal water into an artificial impoundment, however, a permit is being obtained from the Montana Department of Fish, Wildlife, and Parks in the remote possibility that an accidental overflow into State waters could occur.

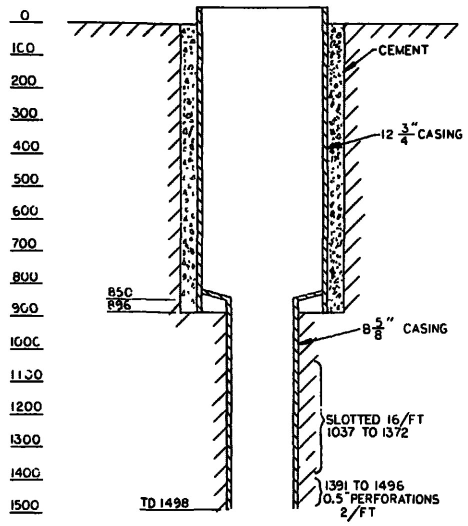
RESOURCE EVALUATION

Geophysical investigations were accomplished with a Resource Evaluation conducted by the Montana College of Mineral Science and Technology in conjunction with the Montana Bureau of Mines. Their charge was to determine a suitable well site, hopefully on the Warm Springs State Hospital property.

This evaluation consisted of a gravity and resistivity survey in the immediate area of the existing hot springs mound; evaluation of existing reports, maps, surveys, and studies of the immediate Warm Springs area; and review of two independent studies of the Deer Lodge Valley. Three probable faults were mapped running northeast to southwest and north to south. The final drilling location was chosen at a site northeast of the existing hot springs mound within 100 feet of the steam plant and a well rig was moved onto the site on October 11, 1979.

WELL DRILLING

Drilling proceeded through December 5, 1979 to a total well depth of 1,498 feet. A cemented surface casing of 12-3/4" O.D. was run to 896 feet and 8-5/8" O.D. production liner was run from 849 feet to a total depth of 1,498 feet. A slotted production liner with 16 slots per foot (3/16" x 2-3/4") was used from a depth of 1,037 feet to 1,371 feet. Schlumberger logged temperature, dual induction - laterlog, compensated neutron formation density and caliper of the hole for further evaluation and records of the well.



WARM SPRINGS PRODUCTION WELL

Initial preliminary pumping tests indicated that the well was producing considerably less than might be expected from the well log-formation evaluation. A decision was made to perform a hydrochloric matrix acid treatment on the well. A vertical line shaft turbine pump was then installed and pump tests were resumed. Vibration problems plagued the test and a total running of only 52 hours was recorded before removing the pump from the well. Subsequent examination revealed that the eslatomer spiders had failed, the bubbler tube had sheared off and the pump intake screen had been lost downhole.

WELL DEVELOPMENT

An evaluation was conducted on the well to present significant data and to evaluate the well in terms of the project requirements. The two most promising zones of geothermal productivity were identified at levels of 1,110 feet to 1,180 feet and 1,250 feet to 1,340 feet. The well was identified as having low values of permeability (2.84-5.66 millidarcies) and pump tests seemed to indicate wide variations in the production characteristics of the well. With this information it was recommended that the well be reworked and deepened an additional 50 feet to penetrate what is believed to be another zone of hot geothermal water.

This recommendation was followed and the bottom 220 feet of the well was bailed of drilling mud and rock chips. A solid metal item was encountered at the bottom of the well and could not be retrieved thus preventing increasing the hole depth an additional 50 feet. A decision was made to perforate the production liner from 1,391 feet to 1,496 feet with two 1/2" perforations per foot. A television camera was utilized to examine the production liner although the temperature prevented inspection to the total well depth. A proposal for screening was also abandoned as the well had been so plugged with drilling mud that screening would have served no useful purpose.

A submersible pump was intalled and initial testing indicated that the pump sizing was in excess of the producing capacity of the well. Another submersible pump was installed on May 19, 1981 at a setting depth of 987 feet. The well was then tested at rates of 50, 75, 95, and 110 gpm for 100 hours each and nine hours step drawdown tests were run at 25, 50, and 75 gpm. The gpm at 168°F can be maintained.

DESIGN AND CONSTRUCTION

The envisioned concept of utilizing the geothermal resource for both space heating and domestic hot water heating was modified to accommodate only the domestic hot water heating due to the reduced total geothermal resource available. The spent geothermal water is discharged to a wet-lands area being developed for waterfowl and wildlife instead of reinjected as previously considered. The designs of the heat transfer system proceeded with the incorporation of a 316 stainless steel plate type heat exchanger with capabilities for full geothermal pump discharge. A vent and vacuum valve, solids separator, flow indicator, pressure gauges, temperature gauges, and the necessary valves, etc. are used on the geothermal side of the system.

All domestic cold water makeup is routed through the heat exchanger to supply the demands of the Warm Springs facility. A Btu flow meter will compute the total amount of the geothermal resource utilized. Pressure gauges, temperature gauges, and safety devices are incorporated to provide safeguards for the system. A domestic water geothermal recirculation pump is used to provide flow from the existing domestic water recirculation system during times of low water demand.

SUMMARY

The energy extracted from the geothermal resource has been calculated based on a 60% utilization factor of the 70 gpm flow with a temperature reduction from 160°F to 90°F. This energy calculation of 1.47×10^6 BTUH can be further interpreted to a value of 15.52×10^6 cubic feet of natural gas (829.5 BTU/ft^3) replaced per year. The dollar value of this natural gas is $68,000 per year.

The installation was completed during the summer of 1982 and has proven to operate satisfactorily with only minor startup problems. The system has not been operational long enough to track the usage of water as calculated by the Btu flow meter. Further considerations for the use of spent geothermal water have been discussed although no positive action has developed from those discussions.

The development of this demonstration project has provided a show piece for direct use of a geothermal resource. The initial phases of the project provided the impetus to complete the project and present the geothermal energy resource concept to the general public and for their incorporation into similar projects.

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