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EGG-GTH-5573

February 1982

GEOTHERMAL CONVERSION AT VETERANS HOSPITAL, BOISE, IDAHO

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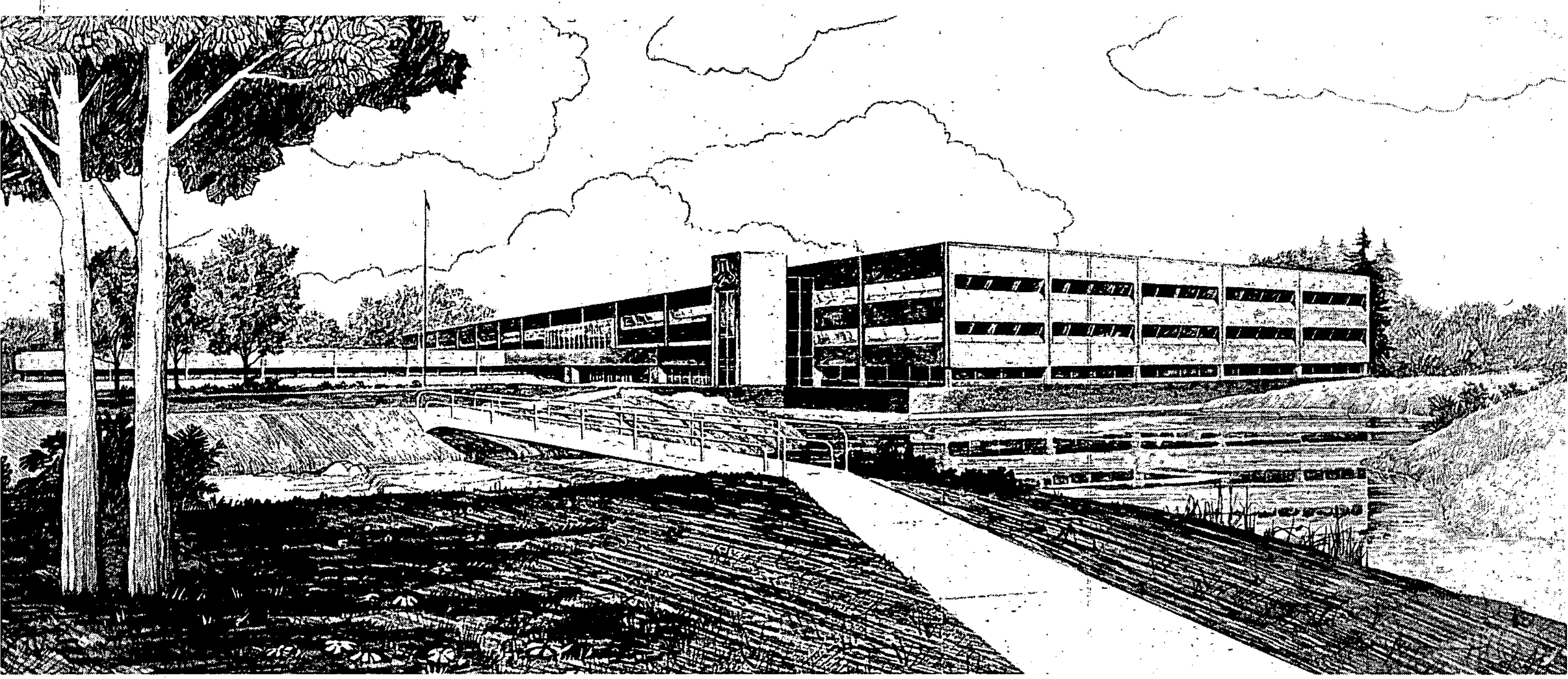
U.S. Department of Energy
Idaho Operations Office • Idaho National Engineering Laboratory



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Prepared for the
U.S. Department of Energy
Idaho Operations Office
Under DOE Contract No. DE-AC07-76ID01570

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ABSTRACT

A geothermal resource near the Veterans Administration Hospital facilities in Boise, Idaho, has been used since the turn of the century for space heating of homes. This report discusses a plan for using this resource in some of the Veterans Hospital facilities. Preliminary cost estimates are presented, economic evaluation criteria are given, and heating system alternatives for the facilities are compared.

FOREWORD

The Geothermal Technical Assistance Program was developed under the premise that the majority of groups or individuals with available geothermal resources do not have the experience or manpower necessary to do a preliminary engineering and economic feasibility evaluation for geothermal energy projects. In order to disseminate technical information and to facilitate expanded use of geothermal energy resources, assistance was provided through FY-1981 in a consulting format on a first-come, staff-and-funds-available basis. Technical assistance can relate to conceptualization; engineering; economics; water chemistry implications for environmental, disposal, and material selection considerations; and planning and development strategies. This report is one of a series adapted from consultation provided to requesters either through in-house efforts or through limited efforts subcontracted to local engineering firms. The Geothermal Technical Assistance (GTA) reports in this series, which are listed below, will be available early in 1982 to those with interest in specific geothermal applications.

GTA Report No.	EG&G Report No.	Title
1.	EGG-GTH-5512	Aquaculture Facility Potential at Boulder Hot Springs, Boulder, Montana
2.	EGG-GTH-5521	Preliminary Geothermal Disposal Considerations, State Health Laboratory, Boise, Idaho
3.	EGG-GTH-5573	Geothermal Conversion at Veterans Hospital, Boise, Idaho
4.	EGG-GTH-5574	Geothermal Applications for Highway Rest Areas
5.	EGG-GTH-5575	Geothermal Applications for a Tannery
6.	EGG-GTH-5599	Preliminary Conceptual Design for Geothermal Space Heating Conversion of School District 50 Joint Facilities at Pagosa Springs, Colorado
7.	EGG-GTH-5617	Selected Geothermal Technical Assistance Efforts (comprising short descriptions of ten space heating projects, five district heating projects, and three heat exchanger projects)

GTA Report No.	EG&G Report No.	Title
8.	EGG-2137	Geothermal Source Potential and Utilization for Methane Generation and Alcohol Production (subcontractor report)
9.	EGG-2138	Geothermal Source Potential and Utilization for Alcohol Production (subcontractor report)
10.	EGG-2139	Potential Geothermal Energy Applications for Idaho Elks Rehabilitation Hospital (subcontractor report)
11.	EGG-2144	Technical Assistance Report on a Geothermal Heating Utility for Lemmon, South Dakota (subcontractor report)
12.	EGG-2145	Economic Analysis for Utilization of Geothermal Energy by North Dakota Concrete Products Company (subcontractor report)
13.	EGG-2146	Geothermal Feasibility Analysis II for Polo School District No. 29-2, South Dakota (subcontractor report)
14.	EGG-2147	Preliminary Feasibility Study of Heating and Cooling Alternatives for Nebraska Western College, Scottsbluff, Nebraska (subcontractor report)
15.	EGG-2148	Inventory of Thermal Springs and Wells Within a One-Mile Radius of Yucca Lodge, Truth or Consequences, New Mexico (subcontractor report)
16.	EGG-2149	Space Heating for Spa Facilities at Ojo Caliente, New Mexico (subcontractor report)
17.	EGG-2150	Geothermal Heated Office Building at Glenwood Springs, Colorado (subcontractor report)
18.	EGG-2151	Final Report--Dickinson Geothermal Study, Dickinson, North Dakota (subcontractor report)
19.	EGG-2152	Cancelled
20.	EGG-2153	Comparison of Two Options for Supplying Geothermal Energy to the Veterans Administration Medical Center, Marlin, Texas (subcontractor report)

GTA Report No.	EG&G Report No.	Title
21.	EGG-2154	Geothermal Utilization at Castle Oaks Subdivision, Castle Rock, Colorado (subcontractor report)
22.	EGG-2155	Space Heating for Twin Lakes School Near Gallup, New Mexico (subcontractor report)
23.	EGG-2156	Pumping Tests of Well Campbell Et Al. No. 2, Gila Hot Springs, Grant County, New Mexico (subcontractor report)
24.	EGG-GTH-5739	Geothermal Deicing of Highways and Bridge Structures
25.	EGG-GTH-5740	Assessment of a Geothermal Application at Tucson, Arizona
26.	EGG-GTH-5741	Heat Pump Systems for Spring Creek, Montana
27.	EGG-GTH-5779	Pipe Selection Guide

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GEOTHERMAL CONVERSION AT VETERANS HOSPITAL, BOISE, IDAHO

INTRODUCTION

Veteran's Administration (VA) Hospital facilities, located near downtown Boise, Idaho, include service facilities of a varied nature, ranging from heating plant, storage, and shop buildings to laundry, culinary, clinical, patient, and staff residential buildings. The hospital complex is located near a geothermal resource that has been used since the turn of the century for space heating of homes. Geothermal wells adjacent to the VA Hospital property produced water at a temperature near 170°F during recent flow tests. Within the last two years, a geothermal space heating conversion has been implemented at the State of Idaho Health Laboratory in Boise, with its space heating requirements supplied by the 170°F geothermal water as the heat source for a closed circulating-water heating system. Chemical constituency of the thermal effluent allows discharge to the Boise River after cooling to reduce local thermal effects on the river.

Available information indicates the existence and availability of 165 to 170°F geothermal water for use at the hospital complex. Water at this temperature is adequate for space heating, as well as domestic and laundry water heating in properly designed systems, if sufficient flow is available. This thermal water could also be used to preheat boiler makeup water.

CONVERSION CONSIDERATIONS

Space conditioning, water heating, and other heating requirements at the VA Hospital are supplied by a gas-fired boiler system, which is being considered for extensive renovation or replacement in 1985. Conversion of the mechanical systems to supply a significant fraction of the total heat load from a geothermal source could conceivably reduce the optimum design capacity, and thereby the cost, of the new steam plant. Of course, if 100% backup capacity to carry the geothermal load is considered necessary, no reduction in capacity or cost will ensue. Additionally, capital costs for geothermal conversions may be increased, since two types of equipment would be provided to allow optional use of steam or geothermal water as the heat source.

Available information indicates that Buildings 27, 67, and 85 offer the best opportunities for conversion to geothermal space heating. The first two buildings are heated by low-pressure steam systems, using vacuum return. Building 85 is heated by a hot water system with a 160°F design temperature; the water is heated in a steam-water heat exchanger. These buildings are all believed to require and use higher pressure steam for special applications such as equipment sterilization. It is expected that these special applications would not be affected by geothermal conversion of the space heating systems.

Building 85

Geothermal conversion of Building 85, the clinical support building, should be easily accommodated. A plate-type heat exchanger could provide closed-system water temperatures approaching the design temperature of 160°F, with geothermal water temperatures near 170°F. Major costs for this conversion would be for the heat exchanger, geothermal service connection to the building, valves, and fittings. A preliminary estimate of these costs are shown in Table 1.

TABLE 1. PRELIMINARY ESTIMATED CONVERSION COSTS, BUILDING 85, DESIGN HEAT LOAD 2,500,000 Btu/hr

Item	Installed Cost ($)
Plate-type heat exchanger	10,000
Valves, fittings, controls, pipe, service connection, system modification	5,000
Total	15,000

Buildings 27 and 67

Buildings 27 and 67, used as patient residential buildings, are heated by low-pressure steam systems. Examination of heating-system drawings for Building 27 indicates that the low-pressure steam system could be modified to a closed circulating-water system. Use of the existing supply and return piping and the existing convectors and radiators would require additional heating capacity. Because of the use of lower-temperature water in place of steam, the design heating capacity would be reduced some 25 to 30%. Installation of hot water coils in ventilation ductwork to preheat ventilating air, and installation of hot water fan-coil units in appropriate locations could make up the lost heating capacity. Fan-coil units could most effectively be placed where increased air circulation and heating are more desired, such as in large bed-wards, near entrances with high infiltration losses, and in locations with large glazed areas. Major costs for converting these buildings would include heat exchangers, circulation pumps, expansion tanks, fan-coil units, piping, fittings, and controls, together with engineering analysis and design costs.

A preliminary estimate of costs for geothermal conversion of the space heating system in Building 27 is based on examination of heating system drawings and the design heat load. The cost for conversion of the space heating system in Building 67 can be roughly estimated by linearly extrapolating the estimated cost for Building 27, according to the design heat loads of the two buildings. These cost estimates are shown in Table 2.

TABLE 2. PRELIMINARY ESTIMATED CONVERSION COSTS, BUILDING 27, DESIGN HEAT LOAD 1,100,000 Btu/hr

Item	Installed Cost ($)
Four 1-hp circulation pumps (2 spares)	500
Two 60-gallon minimum expansion tanks	500
Ten 30-MBh fan-coil units or equivalent	6,500
Miscellaneous pipe, valves, fittings, controls, service connection, system modifications	8,000
Plate heat exchanger	10,000
Steam-water heat exchanger	6,500
Subtotal	32,000
Contingency (25%)	8,000
Subtotal	40,000
Design and Analysis (20%)	8,000
Building 67, design heat load (1,900,000 Btu/hr, $48,000 x 1.9/1.1)	82,000
Total	130,900

The geothermal source could also possibly be used for heating domestic and laundry water and preheating boiler makeup water. The water required for these purposes is estimated to be 7,000 gal/day each for domestic and laundry water, and 2,000 gal/day for boiler makeup. Peak demand for these uses may not occur at the same time, and would not likely relate to average daily use in the same manner. For estimating purposes, however, peak demands are assumed to be 100 gpm each.

Geothermal heating of domestic water and boiler makeup water would require heat exchangers to isolate these systems from the geothermal system. If water chemistry and temperature permit, consideration should be given to using geothermal water directly in the laundry washing cycle and employing appropriate commercial detergents for the water temperature and sanitary requirements.

Major conversion costs to effect these applications of geothermal energy would be for service connections, heat exchangers, fittings, and controls. It was assumed that a single heat exchanger would be required for each of these uses. Costs are summarized in Table 3.

TABLE 3. PRELIMINARY ESTIMATED CONVERSION COSTS FOR DOMESTIC, LAUNDRY, AND BOILER MAKEUP WATER

Item	Installed Cost ($)
Plate-type heat exchangers	20,000
Pipe, valves, fittings, controls, system modification, and installation	10,000
Total	30,000

Assuming a 20°F design temperature drop across the space heating systems, the geothermal water flow that would be required to service the foregoing design heat loads was estimated. From this estimate, sizing specifications and preliminary cost estimates for the geothermal supply and distribution system were then calculated. For estimating purposes, it was assumed that geothermal water would be brought from a supply main at a point near the Fifth and Fourth Street intersections to the hospital complex, and discharged to a return main at the same location. The supply and return mains could be routed either (a) directly to the power plant, then to the laundry and buildings to be heated, or (b) east from the intersection to the buildings, then to the power plant and laundry. The overall distance is approximately the same.

Distribution System

Design heat loads of Buildings 27, 67, and 85 are about 1,100,000 Btu/hr, 1,900,000 Btu/hr, and 2,500,000 Btu/hr, respectively. These heat loads would require geothermal flows of about 110, 190, and 250 gpm respectively, based on a 20°F temperature drop across the respective heating systems. Total flow required for the water heating was previously estimated at 300 gpm. An 8-inch-diameter supply main would allow for a 20% increase in demand, to about 1,000 gpm, compared to the estimated peak demand of 850 gpm for the foregoing conversions. This would allow for expansion of the geothermal system without necessitating an increase in supply line size. Supply line sizes should be such that fluid velocities are below 10 fps, to minimize friction losses. Insulating the supply line would not be necessary, if the pipe were buried below the frost line and the surrounding soil were dry.

Supply and return piping, valve, and fitting costs are based on selection of asbestos-cement pipe and steel valves. Estimated costs include trenching and backfill. These costs are summarized in Table 4.

TABLE 4. PRELIMINARY ESTIMATE OF DISTRIBUTION SYSTEM COST (Asbestos-Cement Pipe, Steel Valves)

Length (ft)	Diameter (in.)		Installed Cost ($)
2,600	8	Pipe	23,000
1,200	6	Pipe	8,400
400	4	Pipe	2,500
		Valves & Fittings	5,000
		Total	38,900

The geothermal conversion could be phased over several years, after the installation of geothermal supply and return lines. Conversion of building heating systems in conjunction with other planned renovations would lessen the disruptions in residentially occupied buildings. Some cost savings may accrue if extensive building renovation affords greater access to heating system components that must be modified.

ECONOMIC ANALYSIS

A preliminary economic analysis of the preceding geothermal conversion was conducted using two independent approaches, i.e., annual worth cost analysis and present worth cost analysis. The annual and present worth cost analyses are based on amortizing capital cost over 25 years, with income and fixed annual costs added, and computing of the present value of capital, future costs, and fossil-fuel savings over 25 years. The discount rate of 10% was used in both analyses. Cost elements and other economic evaluation criteria are summarized in Table 5. Costs and results obtained from the two economic approaches for the various options are summarized in Table 6.

TABLE 5. ECONOMIC EVALUATION CRITERIA

Project life	25 years, no scrap value for geothermal system	
Minimum rate of return	10% cost of borrowed money	
Utilization factors	20% (21 billion Btu/yr) 30% (31.5 billion Btu/yr)	
Unit energy costs	Electricity - 2¢/kWh Natural gas - 23¢/therm, 10% annual escalation Purchased geothermal - $2/MBtu	
Fixed costs	Building conversions	$145,900
	Water heating conversions	30,000
	Distribution system (purchased geothermal option)	38,900
	Distribution system (well option)	20,000
	Production, disposal wells	300,000
	Annual maintenance (purchased geothermal option)	4,300
	Annual maintenance (well option)	5,520
Annual geothermal supply pumping	20% utilization factor	1,700
Annual geothermal circulation pumping	20% utilization factor	300
(Pumping costs increase 50% for 30% utilization factor)		

TABLE 6. COSTS AND COMPARISONS OF HEATING SYSTEM ALTERNATIVES

Alternative	Supply & Disposal Wells		Purchased Geothermal Energy		Natural Gas[a]	
Utilization Factor	20%	30%	20%	30%	20%	30%
Annual heat load (Btu)	--	--	2.1×10^{10}	3.15×10^{10}	2.1×10^{10}	2.1×10^{10}
Capital cost ($)	495,900	495,900	214,800	214,800	--	--
Maintenance ($)	5,520	5,520	4,300	4,300	--	--
Electricity[b] ($)	2,000	3,000	300	450	--	--
Geothermal energy[c] ($)	--	--	42,000	63,000	--	--
Annual worth cost analysis ($)	62,168[d]	63,168	70,271	91,421	120,957	181,436
Present worth cost analysis ($)	564,159[d]	573,236	637,788	829,767	1,097,672	1,646,509

a. Natural gas @ 23¢/therm, 10% annual escalation over 25 years.

b. Electricity @ 2¢/kWh.

c. Geothermal energy purchased @ $2/MBtu.

d. Most economical choice.

From six heating system options, i.e., four combinations of geothermal energy and two combinations of natural gas, the best economic option was confirmed through, and common to both analytical methods employed. The four combinations represent geothermal utilization factors of 20 and 30%, with annual heat loads of 21 billion and 31.5 billion Btu/yr, respectively. Alternative geothermal energy sources were assumed to be: (a) purchased geothermal energy costing $2/million Btu; and (b) drilled production and disposal wells costing $200,000 and $100,000, respectively. Distribution system costs for these alternatives were estimated at $38,800 and $20,000, respectively. Pumping costs were based on annual consumption of 85,000 kWh for well pumping and 15,000 kWh for circulation pumping, at the 20% utilization factor. Electrical consumption increases 50% for the 30% utilization factor. Electricity was costed at 2¢/kWh. For comparison, natural gas was costed at 23¢/therm, initially, and escalated at 10% annually.

Use of constant unit prices for geothermal energy and purchased electrical energy was based on the assumption that except for production/reinjection well pumping, electrical charges would be relatively small, and that a long-term contract for purchase of geothermal energy would be negotiated. Price escalation for natural gas is expected to be markedly greater than that for electricity or geothermal energy over the 25-year life of the project. Costs of $300,000 for two production wells and one injection well are believed to be a conservatively high estimate for the probable 1,000 to 1,200-foot depth to the geothermal resource. Deep-well drilling costs are currently escalating at a rate near 25% per year. A preliminary indication that resource development may be competitive with purchase of geothermal energy under these conditions warrants further investigation.

The most cost-effective option appears to be the geothermal option, wherein the heating system design point represented 21 billion Btu/yr, and wells were to be drilled. It is of interest to note that the best economic choice is only slightly better than the geothermal well-drilling option delivering 31.5 billion Btu/yr. The fixed costs were held constant for this latter case, and equal to the lower geothermal-heat duty system. The balance was therefore in favor of the lower-heat duty option, due to the greater pumping variable cost ascribed to the higher geothermal-heat duty option. The natural gas fuel options were markedly the worst economic choices throughout the entire analyses. Available cost information and cost projections do not allow a clear choice between purchase of geothermal energy and developing the on-site resource. If more precise information on well cost, unit price, escalation rates for energy, and the annual heat load becomes available, a more distinct choice may become apparent, and a return-on-investment analysis can be performed.