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HEATING THREE BUILDING COMPLEXES IN SCOTTSBLUFF, NEBRASKA, WITH GEOTHERMAL ENERGY - DESIGN OPTIONS AND ECONOMICS

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ABSTRACT

The topic of this paper is the feasibilty of heating three building complexes with geothermal energy. The complexes are a college, a hospital and the high schools of Scottsbluff, Nebraska. The resource is assumed to be 180°F water from aquifers 4700 to 5200 ft below the surface; the static water level is expected to be about 2000 ft below the surface. Reinjection will be necessary. We discuss some of the design probelms as well as the economics of utilizing this resorce. Various scenarios for heating the complexes are explored. The payback periods in terms of current energy prices range from 9 to 32 years. Using DOE projected fuel prices the payback periods range from 6 to 11 years. The most cost effective project would be to heat the College and part of the Hospital with geothermal energy.

INTRODUCTION

During the last year our organization has been working towards the commercialization of the Nebraska geothermal resource (Gosnold and Ingersoll, 1982). In the Spring of 1981 we were commissioned to study the heating/cooling alternatives of Nebraska Western College (NWC) in Scottsbluff Nebraska (AGEA, 1981). The geologist's report indicated that flow rates of 150 gpm and temperatures of 180° F are quite probable. The wells would have to to be drilled to a depth of 5200 ft and the artesian head is expected to bring the water to within 2000 ft of the surface. The water is expected to contain 5 to 15 ppm dissolved solids and reinjection of the used geothermal fluids is anticipated. The economic analysis indicated that an additional user would decrease the payback period.

Early in 1982 a second study was commissioned by a user group representing the College, the West Nebraska General Hospital (WNGH) and the Board of Education. This second study was completed in April of 1982 and the results were presented to the governing bodies of those institutions (AGEA, 1982). A report on the retrofitting of the Hospital was available from Kirkham, Michael & Associates (KM&A, 1982). In the second AGEA report this information was utilized together with studies on the College and the High Schools to form district heating schemes and for the purpose of cost-benefit analysis. In addition this study contains a fairly detailed discussion of the relevant geology in the Scottsbluff region .

DESCRIPTION OF THE PROJECT

Figure 1 shows the relative locations of the buildings. The letters A,B,C,D,E label the individual sites. At

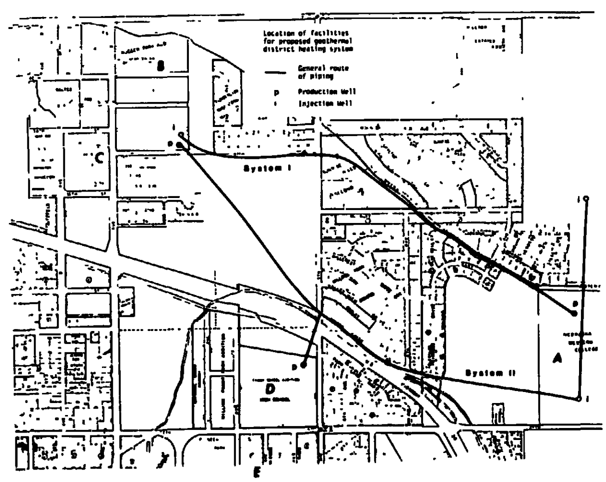

Figure 1 . A portion of Scottsbluff showing the locations of the three complexes.

the upper left is the hospital complex (labelled B and C); at the lower left is the School complex consisting of the Senior High School with associated Splash-Arena (labelled D) and the Junior High School (labelled E); at the lower right is the College (labelled A). The maximum distances between complexes are somewhat over one mile.

All of the buildings are heated with natural gas. The College (NWC) consists of three buildings which are mostly on one level. The bulk of the heat is delivered by circulating hot water.

The schools consist of the Junior and Senior high schools (JHS and SHS). Both buildings are heated with low pressure steam. The SHS has a modern steam heating system ; the JHS is an older building with cast iron steam radiators.

The hospital has a north and a south building. Both utilize low pressure steam in their mechanical systems and the main heating load is the ventilating air. The north building is a large multistory structure; the south building is a smaller and older structure.

To gain an insight into the economics of geothermal heating we first assumed that each complex is heated from its own associated well system. Next we explored the possibilities of supplying more than one user from one or more geothermal well.

. There are many possibilities for district heating schemes. We choose to develop two of them and call them System I and System II. In System I we supply heat to the College and Hospital Complexes from one well located near the College; in System II we attempt to heat all three complexes from two production wells.

GENERAL DESIGN CONSIDERATIONS

Standard engineering methods were used to arrive at heating loads from the gas consumption and degree day data and from the ratings of the mechanical systems in place. Generally the designer's objectives were to heat the buildings with geothermal energy for outside temperatures above 20° F and to supply additional heat from the existing boilers when the ambient temperature drops below 20° F. In this way better than 90% of the heat can be supplied geothermally and the geothermal system operates at full load for a greater period of time.

Electricity costs for lifting and reinjecting the geothermal waters are a major expenses. Our calculations will assume that the pump is sited about 150 feet below the piezometric surface to allow for drawdown . We will also make allowances for a reinjection plant. The design should be such that the flow rate can be regulated. One way would be to throttle the flow with a valve, another way would be to install variable speed pumps and a third way would be to utilize a surge tank from which the geothermnal fluids can be drawn on demand. Our calculations will be based on the last option.

COSTS

The well costs were particularly difficult to pin down. For scenarios requiring flow rates of 150 gpm we used \$321,600 for the production well and \$143,000 for the reinjection well (P. Roberts, 1982) with an additional 10% for design and other considerations. For the College we used a slightly smaller figure, \$269,000, for the production well. We used \$400/hp (EG&G, 1981) to compute the price of pumps. The computed pump prices compare well with the actual prices. Maintainance expenses were taken as 3% of capital costs excluding retrofit costs.

Results

Table 1 (see next page) summarizes the relevant parameters for the various situations. There has been some controversy about the siting of the pump. Some persons believe that the pump has to go near the bottom of the well. Because we could not completely resolve this issue it was decided to show the effects of lowering the pump for System I. System IA assumes that the pump is sited near 2000 ft and System IB is for the pump placed at 5200 ft.

The next table (see Table 2) displays the payback periods. Column 2 lists the payback periods in terms of current energy prices. There is a wide range of payback periods, and if one assumed that the price of gas were to remain constant then only System I would be deemed attractive. If, however, one were to postulate rising gas prices then some of the other scenarios would also be acceptable.

ECONOMIC PROJECTIONS

The U.S. Department of Energy has been making projections of fuel prices which are published in its' report to Congress (U.S. Department of Energy, 1981). In our calculations we used the figures representing the midrange of those projections for commercial consumers. For current rates we used local 1982 prices. The projected prices are in 1980 Dollars and make no allowance for inflation. These numbers are displayed in Table 3.

Table 1. Summary of system parameters.

System	Flow Rate gpm	Total Head ft	Prod. & Inj. hp	Electricity Usage Well Pumps	Electricity Usage Other 10^5 kWh	Electricity Usage Total	Oper. Electr. 1982	Exp. Maint. 10^3 $	Gas Savings 10^3 CCF	Gas Savings 10^3 $	Cap. Inv. 10^3 $
College	100	2150	70 30 100	3.77	---	3.77	13.9	15.3	185.5	53.8	697.[illegible]
Schools	200	2300	160 70 230	8.66	.56	9.21	32.0	18.8	184	82.4	1,080
Hospital	170	2200	130 60 190	7.16	.16	7.32	27.1	17.3	373.6	108	1,238
System-IA	150	2250	115 50 165	6.22	.143	6.36	23.5	20.3	472.5	137	1,285
System-IB	150	5500	275 50 325	12.2	.143	12.4	45.9	22.7	472.5	137	1,342
				(System IB is the same as System IA except that the pump is at 5200 ft.)							
System II	235	2500	200 80 280	10.6	1.32	22.4	82.9	48.8	845	244.5	2,894
	x 2 470		x 2 560	x 2 21.2							

Table 2. Payback periods in years.

System	Current Energy Prices	Projected Energy Prices	Projected Energy Prices & 5% Infl.
College	28	9	8
Schools	32	11	9
Hospitals	19	8	7
System IA	9	6	5.5
System IB	10	-	-
System II	26	9	8

Table 3. Energy prices.

		1982	1985	1990	1995
Nat. Gas.	$/CCF	0.29	0.519	0.726	0.857
Electr.	$/kWh	.037	.0591	.0609	.0635

Using these prices we arrive at paybacks summarized in Table 2, column 3 and if one assumes an annual inflation rate of 5% one arrives at the figures in column 4.

We choose to include a more complete analysis for System I because it has the shortest payback period. Figure 2 shows the payback using projected energy prices and the effects of various interest rates; in Figure 3 an inflation rate of 5% was included. Figure 4 shows the effect of lowering the pump to 5200 ft and also the effect of decreasing electricity costs by 30%.

CONCLUSIONS

Our main concerns are:

1. The uncertainties in the placement of the pump.
2. Problems associated with the reinjection of the fluids.
3. Possible difficulties in reach- flow rates greater than 150 gpm.
4. Corrosion and precipitation of solids because of the chemistry of the geothermal fluids.

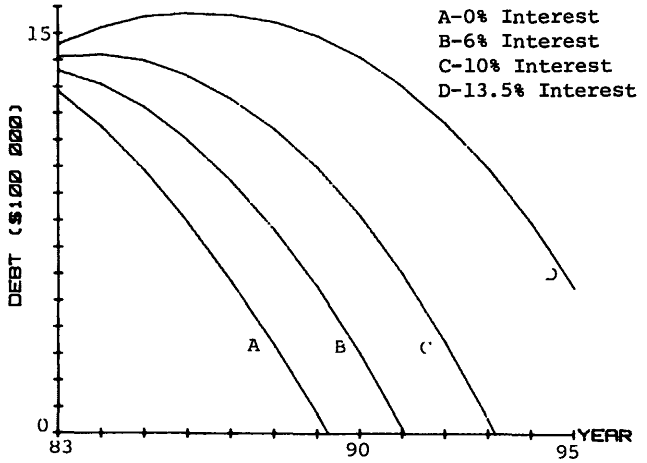

Figure 2. Indebtedness as a function of time with projected energy prices, zero inflation and showing the effects of various interest rates.

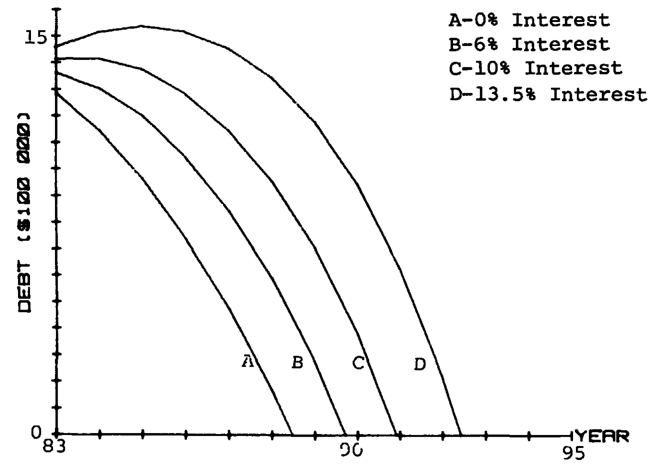

Figure 3. Indebtedness as a function of time with projected energy prices , 5% inflation and various interest rates.

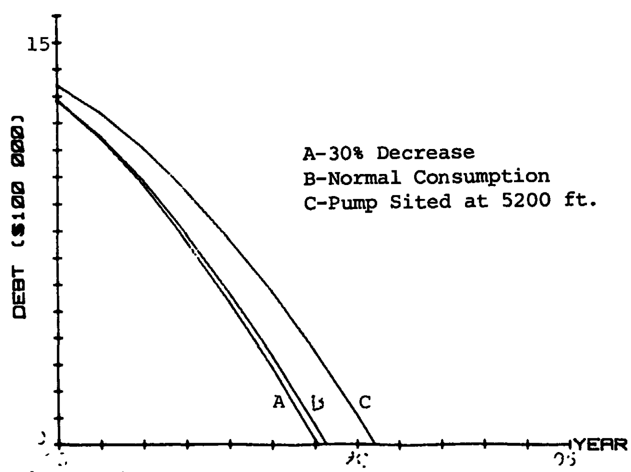

Figure 4. Indebtedness as a function of time showing the effects of varying electricity consumption.

These problems are commonly encountered in geothermal projects and they can be circumvented. One certainly should avoid exposure of the geothermal fluids to the atmosphere. However, relyable information on the extent of these difficulties will not be available till the first well is drilled and tested.

To minimize the risks we recommend that the pilot project be a system with a short payback period and one which is relatively insensitive to variations in electricity costs. System I would be the best option.

System I also has the virtue of being relatively simple from an engineering viewpoint. Because the heating system of the College is designed to operate at an average temperature of 160°F the retrofitting there is minimal if one uses the 180° F water to heat the College first. The water leaving that complex will still be above 140°F which is warm enough to heat a considerable portion of the hospital.

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