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GEOTHERMAL DISTRICT HEATING AND COOLING OF HOTEL/CASINOS IN DOWNTOWN RENO, NEVADA

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ABSTRACT

In this paper, potential revenues from the proposed geothermal district heating/cooling system for the hotel/casino complexes in downtown Reno, Nevada are estimated by analyzing their actual electricity and natural gas bills during 1993 through 1994. The geothermal system appears to be feasible, and financially very attractive. The geothermal district system can meet the entire heating and cooling requirements of the hotel/casinos, generating total potential revenues of $3,486,000 per year. Also, other buildings around the downtown area such as Saint Mary's Hospital, several motels, business complexes, Washoe County School District Building, and even the UNR campus will add extra potential revenues, if these buildings are connected to the geothermal grid. Since most buildings around the downtown use central heating and cooling system, the retrofit costs for the both system should be minimal.

INTRODUCTION

One of the world's alternative energy sources is geothermal energy sometimes called the earth's heat. If our planet was cooled by 1°C, the heat released by the world would be sufficient to meet the world's energy needs for some 40 million years. This was pointed out by Armstead (1973) to allow an imagination for the magnitude of the potential of geothermal energy. Geothermal energy is used in many applications such as power generation, district heating and cooling, domestic hot water supply, domestic services, farming and aquaculture, mineral extraction, balneological purposes, and industry.

To give some historical perspective, the hot springs were the first use of geothermal energy. They have been used for balneological proposes for centuries. There was no development on the use of geothermal energy until the beginning of this century. In 1904, geothermal steam was first used for generating electric power at Larderello, Italy. That power plant had a capacity of 250 kW and operated until 1914. After the World War II, the power generation from geothermal energy has been utilized in other parts of the world such as New Zealand, the United States of America, and Japan. In these countries, electric power plants were commissioned in the 1960's. Geothermal energy was begun to be used for district heating and domestic hot water in Iceland in 1943. The Icelanders started producing electric power in 1969. Today, geothermal energy is being successfully used for space heating and cooling in residential and commercial buildings, as well as power generation throughout the world (Chistopher, 1978).

The Mineral Land Classification Committee of the U.S. Geological Survey conducted a study to determine the available geothermal energy for generating power in the United States. The study stated that there are 108 resource areas (have potential to generate power) in 11 western states, totaling 3,380,356 acres. These western states are Alaska, Arizona, Northern and Southern California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Washington.

Nevada is one of the states whose geothermal energy has a great potential. The hot springs were used by the mines of the Comstock Lode at Virginia and several other mining camps. In the Stillwater area of west-central Nevada, steam and hot water have been used to heat residential building in farming areas. At Steamboat Hot Springs located in the south of Reno, the hot water is used as a safe way to melt explosives. In Nevada, many drillings have been made before 1965. Three of them located at Beowawe, Brady's, and Steamboat were significant. Water temperatures were higher than 350°F. Today, there are about 100 hot springs in Nevada. The Mineral Land Classification Committee of the U.S. Geological Survey designated 13 known geothermal resource areas, in Nevada which are available to produce power. These are good enough to generate electric power (Anderson, 1972).

Downtown Reno is an area concentrated with high-rise hotels/casinos, and is very suitable for district heating and cooling. There are 9,179 hotel rooms in the downtown area, and these rooms are mostly heated by central hot-water heating systems. A comprehensive study conducted in 1981 (prepared by Trans Energy Systems, Inc. for Oregon Institute of Technology, Geo-Heat Center) concluded that a geothermal district heating system for the downtown area is technically and economically feasible. In this study, the economical aspects of a geothermal heating and cooling system which will serve primarily the downtown hotel/casinos are investigated.

Other potential customers in the area such as Saint Mary's hospital, several motels, business complexes, Washoe County School District Building, and even the UNR Campus as well as several buildings in close proximity to the pipeline such as the Clarion hotel/casino and many schools are also potential major customers. Therefore, the prospective revenues are much larger than the projected revenues from downtown hotel/casinos, and the project should proceed with optimism.

PEAK HEAT LOAD AND ANNUAL HEAT CONSUMPTION

The 1981 report mentioned above for geothermal heating of downtown Reno was prepared by selecting potential users from aerial and City planning maps and published building and demographic information, and obtaining energy consumption data from the utility companies as well as the prospective customers. The report stated that 20% of the hotel/casino complexes have steam or individual heating systems which may be expensive to retrofit, but the remaining 13 hotel/casinos with 3,743 rooms are well-suited for geothermal heating. The downtown area has experienced major growth during the last 15 years, and the downtown hotel/casinos today have 9,179 rooms.

For 3,743 rooms, the peak heat load and the yearly heat consumption were determined to be 150×10^6 Btu/h and $310{,}700\times10^6$ Btu/year, respectively. Then the peak load and yearly consumption "per room" are calculated to be

Peak heat load per room
= (Total peak heat load)/(Number of rooms)
= (150×10^6 Btu/h)/(3,743 rooms)
= 40,075 Btu/h-room

Annual heat consumption per room
= (Total annual consumption)/(Number of rooms)
= ($310{,}700\times10^6$ Btu/year)/(3,743 rooms)
= 83.0×10^6 Btu/year-room (or 830 therms/year)

The heat load includes space heating as well as domestic hot water for an average year. The peak load and the annual heat consumption do not change much over the years, and thus these values can be used with confidence for a preliminary study.

Assuming 90% of the 9,179 rooms (i.e., 8,261 rooms) are connected to the geothermal grid, the peak load and the annual energy consumption are determined to be

Total peak heat load
= (Peak heat load per room)(Number of rooms)
= (40,075 Btu/h-room)(8,261 rooms)
= **331×10^6 Btu/h** (3,310 therms/h)

Total annual heat consumption
= (Annual consumption per room)(Number of rooms)
= (83.0×10^6 Btu/year-room)(8,261 rooms)
= **$685{,}700\times10^6$ Btu/year** (= 6,857,000 therms/yr)

This is the actual amount of heat that needs to be supplied to the casinos. A furnace would require about 25% more therms of natural gas to account for the combustion efficiency.

The cost of the geothermal energy must be lower than that of natural gas to sell it to the customers. Since geothermal energy supplied to the user is entirely usable, an efficiency of geothermal heaters can be assumed to be 100%. The average efficiency of natural gas fired heaters is about 65-80%. In this case, the use of the geothermal energy represents a cost savings of 20 to 35% to the customer by assuming an equal cost of geothermal and natural gas.

Taking the average price of natural gas to be $0.424/therm, the projected annual revenues from the hotel/casino complexes for all kinds of heating becomes

Potential Annual Revenues
= (Price of energy)(Annual Energy Usage)
= ($0.424/therm)(6,857,000 therms/year)
= **$2,907,000/year**

That is, if 90% of the hotel/casino complexes in the downtown area get connected to the geothermal grid at a price discounted by 20 to 35% and meet their entire space heating and hot water requirements from geothermal energy, the proposed project will generate a total of 2.907 million dollars per year.

The annual heat consumption per room was determined above to be 830 therms/year. Assuming a furnace efficiency of 75%, the amount of natural gas consumed per room is

Annual natural gas consumption per room
= (Annual heat consumption)/Efficiency
= (830 therms/year)/0.75
= 1107 therms/room-year

For an average price of $0.424/therm for natural gas, the annual heat cost per room becomes

Annual natural gas cost per room
= (Annual consumption)(Price per therm)

Table 1 Total Electricity and Natural Gas Usage of a 351-room hotel/casino in Downtown, Reno for 1994.

MONTH	ELECTRICITY (From utility bills)		NATURAL GAS (From utility bills)	
	Usage, kWh	Cost, $	Usage, Therms	Cost, $
January	590,400	35,419	48,144	19,531
February	576,960	34,883	44,473	18,717
March	618,240	36,519	42,829	17,860
April	580,800	37,057	35,447	15,514
May	591,360	37,595	31,797	13,664
June	696,000	42,947	28,871	12,451
July	709,440	44,803	22,114	9,673
August	702,720	44,963	20,865	8,926
September	703,000	43,586	29,000	12,289
October	610,000	37,820	33,000	13,984
November	590,000	36,580	43,000	18,221
December	620,190	38,452	51,177	21,686
Total	**7,589,110**	**470,626**	**430,717**	**182,516**

Average Unit Costs: Electricity: $0.0620/kWh, Natural Gas: $0.424/therm

Annual Natural gas cost per room = (Total natural gas cost)/(No. of rooms)
= ($182,516/year)/(351 rooms)
= **$520/room-year**

Annual Natural gas usage per room = (Total natural gas usage)/(No. of rooms)
= (430,717 therms/year)/(351 rooms)
= **1227 therms/room-year**

Average natural gas cost during summer (June, July, August, Sep)= $10,835/month

Average natural gas usage during summer = 25,213 therms/month

Monthly natural gas cost per room in summer = ($10,835/month)/(351 rooms)
= **$30.9/room-month**

Monthly natural gas usage per room in summer = (25,213 therms/month)/(351 rooms)
= **1227 therms/room-year**

= (1107 therms/year-room) ($0.424/therm)
= **$469/year-room**

The values above are average values per room. They account for all the energy used in the gaming area, restaurants, laundries, and kitchens.

Verification

The values above can be verified by comparing them to the actual amounts of natural gas consumed in hotel/casinos, and their cost. In Table 1 we present the total annual natural gas consumption of a 351-room Hotel/Casino, and analyze it. We find that

Annual natural gas usage per room
= 1227 therms/year-room

Annual natural gas cost per room = $520/year-room

which differs from the proposed values of 1107 therms and $469 per year per room by only 10.8%.

We are also told that a 2000-room hotel/casino in Reno spends a total of $805,000 per year on natural gas for heating. This corresponds to $403 per year per room, which differs from the projected value by 14%. The slightly lover heating cost of the hotel/casino is not surprising since large buildings are inherently more energy efficient, and consume less energy per room. Note that the proposed values are almost at the mid point of the actual values of the hotel/casinos, and can be used as representative values for all the hotel/casinos with confidence.

ANNUAL ENERGY CONSUMPTION FOR AIR-CONDITIONING

Geothermal energy can also be used to cool the hotel/casinos in the downtown area. This can be done in several ways:

I. Use the hot water as the energy source in absorption cooling systems.

II. Install a water chilling facility at the geothermal source site, and produce chilled water at the site and circulate it through a separate loop year around. This option will require the installation of a 4-pipe system (2 supply and 2 return lines).

III. Produce chilled water at the site, but circulate it in summer months only when the demand for cooling is the highest. In this case a 2-pipe system will be used, and chilled water will be circulated during June, July, August, and September while hot water will be circulated during the remaining 8 months. With this option no hot water can be supplied in summer months.

Before we discuss these options, we need to know the potential revenues from the hotel/casinos in the downtown area. For this purpose we have obtained and analyzed the electricity consumption of a hotel/casino. The bar chart in Figures 1 shows the average daily electricity usage for the hotel/casino, and it is photocopied directly from the power bills. It is clear from the figure that the electricity usage is relatively steady during winter months, but increases in summer months, reaching a peak in July or August. The rise above the winter base levels is due to air-conditioning, and the cost of air-conditioning can be determined from these bills by quantifying the excess consumption in summer. This is done for all three hotel/casinos, and their average can be taken as the representative values for all hotel/casinos, as shown in Table 2.

Therefore, based on the electricity usage of 3 hotel/casinos in the downtown area, we conclude that a hotel/casino consumes 1,571 kWh of electricity per year per room for air-conditioning which costs $93.4. Offering the same service at a 25% discount, the potential revenues for air-conditioning from 8,261 rooms become

Potential Annual Revenues
= (Revenue per room)(Number of rooms)(Discount)
= ($93.4/year-room)(8,261 rooms)(0.75)
= **$579,000/year**

That is, if 90% of the hotel/casino complexes in the downtown area get connected to the geothermal grid (hot water for absorption cooling or chilled water for direct cooling) at a price discounted by 25% and meet their entire air-conditioning needs from it, the proposed project will generate a total of 579,000 dollars per year, which is about one-fifth of the potential revenues for heating. The one-to-five ratio for air conditioning-to-space and water heating is also realistic for Reno.

We have called three hotel/casinos, and talked to two maintenance directors about their heating and air-conditioning systems. They indicated that their systems are electricity driven (instead of heat driven like absorption systems) and confirmed that the excess electricity used in summer is due to air-conditioning.

They also said that they need to air-condition certain parts of the hotel/casinos even during winter months, but they use the cold ambient air for this purpose instead of refrigeration.

In the light of the analysis above and the conversation with casino personnel, we conclude the following regarding the three possible ways of geothermal cooling:

1. The potential revenues from geothermal cooling are much smaller than the potential for geothermal heating. Therefore, the economics of

Estimating the annual electricity usage and cost for air conditioning on the basis of the average daily electricity usage bar chart above for a one-year period.

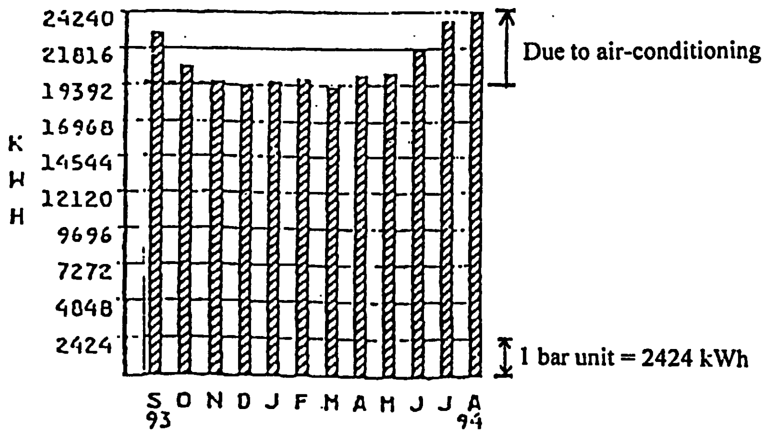

Figure 1 Average daily use of electricity by months for a 12-month period for a 351-room hotel/casino in Reno for 1994.

This hotel/casino has 351 rooms, and the average unit cost of electricity is \$0.0620/kWh. It is assumed that the excess electricity usage in summer months is due entirely to air conditioning, and the entire cooling needs in winter months are met by ambient air.

Each unit (division) of a bar corresponds to 2424 kWh/day.

No. of bar units = (Sum of the No. of unit bars for each month)(Days/month)
=(1.4+0.6+0+0+0+0+0+0.2+0.2+1+1.8+2)(30.5 days/month)
= 164.1 bars/year

Air-cond usage = (Total No. of bar units)(kWh per bar unit)
= (164.1 bars/year)(2424 kWh)
= 397,778 kWh/year

Air-cond cost = (Annual air-cond usage)(Unit cost of electricity)
= (397,778 kWh/year)(\$0.0620/kWh)
= \$24,662/year

Air-cond cost per room = (Air -cond cost)/(No. of rooms)
= (\$24,662)/351
= **\$70.3/room-year**

(Air-cond usage per room = (\$70.3/room-year)/(\$0.062/kWh)=1134 kWh/room-year)

Table 2 Air-conditioning load and cost of hotel/casinos.

Hotel/Casino	Air-conditioning load kWh/year-room	Air-conditioning cost \$/year-room
A 351-room hotel/casino in downtown Reno	1,134	70.3
A 565-room hotel/casino in downtown Reno	1,964	119
An 836-room hotel/casino in downtown Reno	1,615	101
Average	**1,571 kWh**	**\$93.4**

2. The idea of circulating chilled water in summer and hot water in winter in the pipeline does not warrant any further consideration. As shown in the analysis following Table 1, the hotel/casinos use $30.9/month worth of heat per room even in summer, which adds up to $123.6 per room for a 4-month summer period. Even after 25% discount, it becomes $93 per room which is equivalent to the potential revenue for air conditioning per room for the entire summer. Therefore, under best conditions, the potential revenues gained from chilled water will only make up the revenue lost by not selling heat in summer. The cost of producing chilled water will make this project a money loser.

3. The outlook for direct geothermal cooling with pre-chilled water does not look very promising. Therefore, the additional cost of the proposed 4-pipe system (such as digging an additional 6-ft deep ditch for the chilled water loop to keep 3-ft distance between the hot and chilled water for a system which will be used only 4-months per year, installing a large chilling plant at the premises, and the electricity cost to circulate the chilled water) must be determined carefully before giving this idea serious consideration. We are not optimistic, but again an engineering analysis may prove us wrong.

4. Absorption cooling at end use points is a viable option. But we suspect most hotel/casinos are currently using vapor-compression systems which operate with electricity instead of heat, and converting to heat driven absorption refrigeration system may require a complete overhaul of the existing system. Noting that space is at a premium in the downtown area, promoting the installation of absorption cooling systems may not be easy. But absorption cooling makes a lot of sense since the heat used for space heating in winter can now be used for space cooling, making best use of the geothermal resource year around. However, it may require the hot water to be supplied at a much higher temperature.

CONCLUDING REMARKS

The proposed geothermal district heating and cooling system for the hotel/casino complexes in downtown Reno with 9,179 rooms appears to be feasible, and financially very attractive. The geothermal district system can meet the entire heating requirements of the hotel/casinos, generating potential revenues of $2,907,000 per year. The geothermal system can also meet the entire air-conditioning needs of the hotel/casinos, generating potential revenues of $579,000 per year. Most buildings around the downtown area use central heating systems, and the retrofit costs for heating and cooling systems should be minimal. Our findings confirm the recommendations of a 1981 study conducted by Oregon Institute of Technology on Casinos/Hotels in Reno.

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