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GEO-HEAT CENTER

DISTRICT HEATING SYSTEM
City of Caliente, Nevada

June 1984

OREGON INSTITUTE OF TECHNOLOGY
A Geothermally Heated Campus
KLAMATH FALLS, OREGON 97601

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DISTRICT HEATING SYSTEM
City of Caliente, Nevada

June 1984

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MASTER

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DISTRICT HEATING SYSTEM City of Caliente, Nevada

INTRODUCTION

In 1980 the Geo-Heat Center of the Oregon Institute of Technology made a feasibility study of the geothermal resource in Caliente, Nevada, with an installation of a district heating system for the city in mind. Assuming that a 160°F geothermal source capable of delivering a peak load of 850 gpm from a relatively shallow depth could be located within or near the city boundaries, it was found that a geothermal district heating system for the city would be economically feasible. These results were described in a Geo-Heat Center report entitled "District Heating System for the City of Caliente, Nevada" which was prepared in February of 1980.

The Caliente district heating project has not yet been carried out. Studies of the geothermal resource have, on the other hand, been continued by the drilling of two geothermal test wells in Antelope Canyon approximately one mile north of the town in January 1983. Later that same year, in June 1983, the third well was drilled in the same area. Tests of these wells have indicated that the Caliente geothermal aquifer can sustain the pumping of over 1000 gpm of water at 170-180°F indefinitely. This temperature is somewhat higher than assumed in the 1980 feasibility study and the water quantity is also more than required for the district heating system.

In view of these results as well as changes which have taken place in the Caliente community since 1980, an updated feasibility study of the district heating system has been requested. This report describes the study.

SUMMARY OF CONCLUSIONS

The study was made in two parts, Option 1 and Option 2. Option 1 is a district heating system for the city of Caliente only, whereas Option 2 assumes making 140°F water available to the Mark West Development, about five miles to the west of the city. The city district heating system is

based on a supply water temperature of 175°F and 120°F return temperature.

The capital cost estimate for Option 1 is \$3,140,000. The resultant savings in conventional energy cost over a 20 year project life, assuming 12% bond financing, show a present worth of \$4,074,000. This shows that the project should be economically feasible.

The capital cost for Option 2 is estimated to be \$4,230,000. The additional cost of Option 2 over Option 1, \$1,090,000, will have to be recovered by the fee charged to the Mark West Development users for the water made available to them. Since, however, this use is unknown an evaluation of the economic feasibility of Option 2 cannot be made at this time.

THE CALIENTE GEOTHERMAL RESOURCE

The city of Caliente applied for and was granted an "Appropriate Energy Technology" grant from DOE for approximately \$50,000. The purpose of this grant was to drill two exploratory wells in the area in hopes of finding the necessary water supply and temperature.

The two wells were drilled in Antelope Canyon, about a mile north of the city of Caliente, in January 1983 (see Fig. 1). The wells, designated CD-1 and CD-2, were drilled into bedrock at 220 feet and encountered hot water in the upper part (40 to 100 feet) and cooler water below (100 to 210 feet). Lithologic logs show that a clay layer in the vicinity of the temperature reversal represents an aquitard which limits fluid mixing. Well CD-1 was drilled with a diameter of 12" to 100 feet and with a 6" diameter below. It was cased with 8 5/8" blank casing from the surface to 60 feet and with 8 5/8" perforated stainless steel screen from 60 to 100 feet. The annular space around the screen was gravel packed and the plain casing was cemented in from the surface to 50 feet. Well CD-2 was drilled as an ob-

ervation well and cased with a 2" diameter steel pipe to bottom. The top 20 feet were cemented in and the bottom 80 feet had torch cut perforations and were gravel packed (Flynn & Larson 1983). Results of pumping tests of well CD-1 conducted in February 1983 indicate that the transmissivity of the geothermal aquifer is very high. Drawdowns of three to six feet recovered within two minutes after pumping was stopped. Constant production tests were conducted where 255 gpm were pumped for periods of up to 72 hours. This rate was determined by the physical limitations of the pump. During these tests the water temperature remained constant at 80°C (176°F), and it was concluded that the aquifer could be pumped at a considerably higher rate.

In June 1983, the city of Caliente drilled and tested a third well, CD-3, in the same general area that CD-1 and CD-2 were located (Fig. 1). This well was a large diameter production well, drilled diameter of 20" and cased with a 16" casing. The well was only 100 feet deep and the top 50 feet of the casing were cemented whereas the bottom 50 feet were perforated and gravel packed. After completion, the well was pumped for 40 hours at rates ranging from 1000 to 1500 gpm.

Sustained pump tests were performed on this well for at least 76 hours from July 5-8, 1983. The results are described in a report by George Ghush (no date) and they indicate that the aquifer can produce 1087 gpm of 170°F water indefinitely.

It appears, therefore, that the Caliente geothermal resource will be more than adequate for the proposed district heating system for the city. Chemical analysis of the water from well CD-1 indicates excellent quality (Table I) so that it may be piped directly to the users for heating or as domestic hot water.

FIGURE 1. Location of geothermal wells, City of Caliente.

TABLE I

Comparison of Caliente drinking water, CD-1 geothermal water, and U.S. Public Health Service standards for limiting values of dissolved constituents for potable waters (from Flynn & Larson 1983a).

Element	US Public Health Service Limits mg/l	Caliente Drinking Water mg/l	CD-1 Geothermal Water mg/l
Arsenic (As)	0.05	0.0124	0.0146
Barium (Ba)	1.0	<0.01	0.088
Fluoride (F)	1.5	1.68	1.48
Manganese (Mn)	0.05	-	<0.01
Sodium (Na)	200	27.6	39.3
Calcium (Ca)	200	53.3	32.12
Magnesium (Mg)	125	6.59	5.2
Bicarbonate (HCO_3)	500	232	215
Chloride (Cl)	250	12.5	4.6
Sulfate (SO_4)	250	5.56	15.1
Nitrate (NO_3)	45	2.26	11.0
Boron (B)	20	0.288	0.04
TDS	1000	395	445

HEATING DEMAND AND MEANS OF HEATING IN CALIENTE

It is apparent that considerable changes have taken place in the means of space heating in the city of Caliente during the last four years since the first feasibility study of a district heating system for the city was made (Geo-Heat Center 1980). These changes may be characterized by the following two main factors:

1. A shift in the means of heating from fuel oil and propane gas to electricity. It is reported, for example, that fuel oil sales have been reduced by 60-70% during the last four years.
2. A marked increase in the number of wood burning stoves after electricity rates were increased in 1980 and 1982.

The prices of the main energy sources for space heating in Caliente are presented in Table II. It is clear that since 1979 electricity has been the most economical means of space heating and still is, in spite of its 98% price increase since 1979. This big increase, on the other hand, is probably the main reason for the increased use of wood burning stoves in the area.

The cost of heating by wood burning is estimated by assuming a heating value of 12×10^6 Btu/cord = 3516 kWh/cord. This is the listed value for air dried (20% moisture) white pine (The Woodburners Catalogue, 1980). The efficiency of wood burning for heating in homes is probably not over 30% and assuming a price of \$40 per cord, the price of heat from wood burning becomes \$0.0379 per kWh.

A survey of the means of heating of residential areas in Caliente was undertaken in April 1984 (Larson 1984). A total of 68 houses were included in the survey of which 63 homes were of the permanent house type and five mobile homes. The results of this survey are shown in Table III. Those familiar with Caliente consider this survey to give a good indication of heating habits in the town today (Keith Larson, personal communication). The importance of wood burning as a source of heat today is evident from the table, bearing in mind that in 1979 it was not included at all as a source of heat in Caliente.

TABLE II
Cost of Heating by Electricity, Fuel Oil, Propane,
and Wood Burning in Caliente, Nevada

	1979	1980	1982	1984
Electricity \$/kWh	0.0177	0.0275	0.0350	0.0350
Fuel Oil \$/gal	0.917*			1.038**
Fuel Oil \$/kWh***	0.0344			0.0389
Propane, Domestic \$/gal	0.590*			0.949
Propane, Domestic \$/kWh***	0.0344			0.0554
Propane, Commercial \$/gal				0.839
Propane, Commercial \$/kWh***				0.0489
Wood Burning, \$/kWh				0.0379

*The 1979 fuel oil and propane prices are average prices as reported in the 1980 District Heating Report for Caliente (GHC 1980).

**The 1984 fuel oil price is an average of the cost of stove oil (#1 diesel) and furnace oil (#2 diesel).

***The cost of fuel oil and propane in terms of \$/kWh is based on heating values of 140,000 Btu/gal for fuel oil and 90,000 Btu/gal for propane, and a combustion efficiency of 65%.

TABLE III
Results of a Survey of Residential Heating in
Caliente, Nevada (Larson 1984)

<u>Source of Heat</u>	<u># of Homes</u>	<u>%</u>	<u># of Homes*</u>	<u>%</u>
Electricity	33	48.5	33	48.5
Wood Burning	28	41.2	28	41.2
Propane	2.25	3.3	2.5	3.7
Fuel Oil	4.25	6.3	4.5	6.6
Coal	0.5	0.7		
Total	68	100	68	100

*The coal heated home is considered an exception, not representative of the town as a whole. The last two columns of the table give adjusted values where coal heating is eliminated by including it with the propane and fuel oil heated homes.

In order to evaluate the heating requirements for Caliente the following information was gathered during a site visit on May 2nd and 3rd, 1984:

1. A thorough count of homes, mobile homes, apartment complexes and commercial buildings in the entire town.
2. Total electricity usage in the town from 1979-1984 (Larson 1984) as well as total electricity for commercial accounts and industrial accounts. By assuming the heating season to be a period from October through May the electrical energy used for heating can be estimated.

3. Building sizes at the Nevada Girls Training Center and heating energy needs for the various functions of the Center. This Center constitutes the main part of the electricity usage in Caliente classified under Industrial Accounts.
4. Fuel oil sales in Lincoln County of which Caliente constitutes approximately 35-40%

From the above information an estimate has been made of the heating requirements in Caliente as presented in Table IV. The table does not include the Lincoln County Hospital or the Hot Springs Motel which today are heated by means of geothermal heat from their own wells, nor is the trailer park at the north end of town included as it is heated by hot water from the Aqua Caliente wells.

Table IV also gives an estimate of the means of heating where the results of the heating survey in Caliente (Table III) have been used as a guide. It is reported (Larson, personal communication) that wood burning in mobile homes is not as common as in permanent homes. Consequently, wood burning is assumed to carry only 20% of the heat load in mobile homes compared with over 40% in permanent homes. The relationship between the annual heating load and the peak heat load is determined by the equation (Rafferty 1983):

$$(\text{Peak load, kW}) = (\text{Annual load, kWh/yr}) \times \Delta T / (24 \times DD \times C_D)$$

where DD = Degree Days = 5239 for Caliente (Sakamoto and Clifford 1971).

ΔT = design difference between indoor and outdoor temperature = $70 - T_o$

T_o = design outside temperature = 7°F for Caliente

C_D = correction factor for heating effect vs degree days
 = 0.766 for $T_o = 7^\circ\text{F}$ (ASHRAE 1976, p 43.8)

From Table IV the peak heating load for Caliente is found to be:

$$Q = 1440 + 562 + 2448 + 413 = 4863 \text{ kW}$$

The two swimming pools are not included in the peak load since they are in operation only when space heating demands are at a minimum. Assuming that geothermal water is available at a temperature of 175°F and that it is cooled down to 120°F in a district heating system, the quantity of water needed for

heating is found from the equation:

$$\dot{m} \times 4.187 \times (175 - 120) \times 5/9 = 4863 \text{ kW}$$

which gives $\dot{m} = 38.0 \text{ kg/s} \approx 602 \text{ gpm}$.

The total annual water demand for space heating is found from the equation:

$$\dot{M} \times 4.187 (175 - 120) \times 5/9 = 2200 + 256 + 860 + 164 + 3742 + 631) \times 10^3 \times 3600 \text{ kJ/year, which gives } \dot{M} = 221 \times 10^6 \text{ kg/year} \approx 58 \times 10^6 \text{ gal/year} = 179 \text{ acre feet/year.}$$

TABLE IV
Estimated Heating Requirements and Estimated
Breakdown of Heating Methods in Caliente

	Commercial		Industrial*		Residential	
	Bldgs	Pool**	Bldgs	Pool	Perm Homes	Mobile Homes
Number of Buildings	60				306	50
Average area, square feet	3000	2250		1440	1000	750
Est. peak heat loss, Btu/hr x square feet					27.2	37.4
Est. peak heat loss, W/ square foot	8				8	11
Peak load, kW	1440	(87)	562	(55)	2448	413
Annual load, kWh/yr x square feet	12.2				12.2	16.8
Annual load, MWh/yr	2200	256	860	164	3742	631
Means of heating:						
Electricity, MWh/yr	558	256	573		1850	311
Fuel oil, MWh/yr	821		287		205	124
Propane, MWh/yr	821			164	115	70
Wood Burning, MWh/yr					1572	126

*Two industrial accounts: Nevada Girls Training Center and Union Pacific Railroad. Assume heat load for Union Pacific as 50% of Girls Center. Pool is at the Girls Center.

**This is the municipal pool. For estimating heating loads for pools, see Tables 5 and 6.

HOT TAP WATER DEMAND

It will be assumed that the geothermal water can be used directly as domestic hot tap water. The population of Caliente today is reported to be about 1180 (Caliente Profile 1982/1983). Residential hot tap water requirements are estimated to be about 20 gal/person per day (Rafferty 1983) and the energy requirement for heating this water is about 4.77×10^6 Btu/person per year = 1398 kWh/person per year. The peak requirement is assumed to be 12 gph/home (ASHRAE Handbook, 1976 Systems, Table 6, p 37.11). For 1180 people living in 356 homes, the hot tap water requirements are then as given in Table VII.

The hot water demand for commercial buildings is difficult to estimate and any numbers given here will for the most part be pure guesswork. The basis for the estimates is shown in Table V which is taken from the ASHRAE Handbook, 1976 Systems (Table 6, p 37.11).

The Nevada Girls Training Center is classified as an industrial account by the city of Caliente. The Center is a large user of hot water for various purposes as listed in Table VI. The estimated requirements given in Table VI are based on information given in ASHRAE Handbook, 1976 Systems, Chapter 37. The hot water requirements for the only other industrial account are assumed to be the same as for an office with 25 persons (see Table V).

The annual energy requirements for heating the hot tap water is estimated by assuming heating the water from 50°F to 120°F with 12% energy loss. The energy required is then:

$$\begin{aligned} (\text{gal/year}) \times 8.33 \times (120 - 50) \times 1.12 &= 653.0 \times (\text{gal/year}) \text{ Btu/year} \\ &= 0.1913 \times (\text{gal/year}) \text{ kWh/year} \end{aligned}$$

From the assumptions listed above it is now possible to estimate the hot tap water requirements for the city of Caliente. The estimate is presented in Table VII.

TABLE V
Hot Water Demands for Various Types of
Commercial Buildings in Caliente

	<u>Ave. per Day</u>	<u>Days/yr</u>	<u>Max. per hr.</u>	<u>Number</u>
Motels	20 gal/unit	180	6 gal/unit	26 units
Offices, Stores	1 gal/person	260	.4 gal/person	200 persons
Restaurants*	2.4 gal/av. meal/day	180	1.5 gal/max meals/hr	90/hr, 300/day
Elem. School	.6 gal/student	180	.6 gal/student	180 students**
Pool: fill	48,000 gal/fill	1 (24 hrs)	2000 gph	1 fill/yr
maintain	6600 gal/day	120	660 gph	120 days/yr
showers	900 gal/day	120	180 gal/shower	20 showers

*3 restaurants in town - assume max. 30 meals/hour in each, average 100 meals per day in each.

**Assume 15% of population in elementary school.

TABLE VI
Hot Water Requirements at the
Nevada Girls Training Center, Caliente

	<u>Ave. per Day</u>	<u>Days/yr</u>	<u>Max. per hr.</u>	<u>Number</u>
Residential	12.3 gal/girl	365	5 gal/girl	140 girls
Office	1 gal/person	260	.4 gal/person	8 persons
Cafeteria	2.4 gal/(meals/day)	365	1.5 gal/(meals/hr)	150/hr, 300/day
Laundry	75 gal/unit	260	5 gpm/unit	7 home units
Laundry	900 gal/unit	260	20 gpm/unit	1 comm. unit
Gymnasium	150 gal/shower	260	225 gal/shower	10 showers
Pool: fill	30,240 gal/fill	1 (24 hrs)	1260 gph	1 fill/yr
maintain*	10,080 gal/day	120	420 gph	120 days/yr
showers	720 gal/unit	120	180 gal/shower	10 showers

*Assume average $\Delta T = 10^\circ\text{F}$ between air and pool water and 5 mph wind.

TABLE VII
Estimated Hot Tap Water Requirements
for the City of Caliente

	Peak Load gpm	Annual Use 10^6 gal/year	Energy Use MWh/year
Residential Use	71	8.6	1650
Commercial:			
Motels	3	0.1	
Offices, Stores	1	0.1	
Restaurants	2	0.1	
Elem. School	2	-	
Pool*	(60)	2.2	
Total Commercial Use	7	2.5	478
Industrial:			
a) Girls Center			
Residential	12	0.6	
Office	-	-	
Cafeteria	4	0.3	
Laundry	55	0.4	
Gymnasium	38	0.4	
Pool*	(30)	0.9	
b) Union Pacific Railroad	10	-	
Total Industrial Use	119	2.6	497
TOTAL REQUIREMENTS	197	13.7	2625

*The peak load for the pool is not counted with the total peak load since the pool is open only when space heating requirements are at a minimum.

TOTAL DISTRICT HEATING LOAD FOR CALIENTE

From the foregoing two sections, an estimate is made of the total district heating load for the city of Caliente. The results are summarized in Table VIII. The proposed system must provide the needed heat and hot tap water for

the existing buildings in town plus the projected increase over the 20 year project life assumed in this evaluation. The projected growth rate of the town is assumed to be 1.0% per year resulting in a total increase of 22% at the end of 20 years. The design load for the district heating system is then as given in the last column of Table VIII.

Table VIII
Capacity of District Heating System
in Caliente

Type of Heat		Estimated Existing Load			Total Load	
		Commercial	Industrial	Residential	Existing 100%	Design 122%
Space Heat	Annual Load					
	Energy, MWh	2456	1024	4373	7853	9582
	Flow, acre ft	56	23	100	179	218
	Peak Load					
Hot Tap Water	Annual Load					
	Energy, kW	1440	562	2861	4863	5934
	Flow, gpm	178	70	354	602	735
	Peak Load					
TOTAL	Annual Load					
	Energy, MWh	478	497	1650	2625	3203
	Flow, acre ft	8	8	26	42	51
	Peak Load					
	Energy, kW	72	1220	728	2020	2465
	Flow, gpm	7	119	71	197	240
TOTAL	Annual Load					
	Energy, MWh	2934	1318	6023	10275	12785
	Flow, acre ft	64	31	126	221	269
	Peak Load					
	Energy, kW	1512	1650	3589	6883	8399
	Flow, gpm	185	172	425	799	975

Figure 2 shows a flow diagram for the proposed district heating system for Caliente, giving the peak water flow requirements. The load is divided into three sectors in accordance with the foregoing analysis. The hot water usage is shown separately as this water is returned to the city sewer system rather than to the district heating return line which goes to an injection well.

The two swimming pools, the municipal pool (in commercial sector) and the Girls Center swimming pool (in industrial sector) are included in the system. Their water use, however, is not included in the peak load as the pools are operated only during the time of the year when the heating load is at a minimum. It is assumed that the heating of the pool water will be done by means of heat exchangers rather than by direct mixing of geothermal water with the pool water.

The flow diagram indicates two options which have been discussed for a district heating system for Caliente. The first option is to take the 120°F return water from the city distribution system directly to an injection well without further use. The second option is to mix the return water with unused geothermal water at 175°F. This water will be made available at a temperature of 140°F to the resort area being developed to the west of the city (marked Mark West Development in Figure 2). In order to make the water available at 140°F an additional amount of 408 gpm at 175°F is required. It is assumed that the water will be injected back into the reservoir after being used in the resort area as indicated in the diagram.

DESCRIPTION OF DISTRICT HEATING SYSTEM

The proposed district heating system for the city of Caliente is shown on Figure 3, Distribution Piping Network and Layout. As indicated in the drawing, the supply piping is insulated fiberglass re-

FIGURE 2. Schematic flow diagram of district heating system, Caliente, Nevada.

inforced plastic pipe. Return lines are of the same type if the Mark West Development is included in the system (Option 2). Otherwise, the return piping is uninsulated PVC pipe, normal impact grade. The approximate lengths of pipe required for the Caliente distribution system are shown in Table IX.

Small piping for building connections is not shown in Drawing No. 1. The bulk of this piping will be 3/4" for the residential and smaller commercial users and 1" for the larger users. All supply piping will be insulated steel pipe. Return piping will be uninsulated PVC pipe under Option 1 but if Option 2 is chosen the return piping will be insulated steel. All piping in the distribution is to be buried about 3 feet deep.

TABLE IX
Approximate Lengths of Piping Required
for District Heating Distribution Systems
in Caliente. All Lengths are in Feet.

<u>Pipe Size</u> <u>inches</u>	<u>Supply Lines *</u>		<u>Return</u> <u>Lines</u>
	<u>Option 1</u>	<u>Option 2</u>	
10	-	4710	-
8	4710	1920	2495
6	3565	4810	5370
4	2770	2100	2675
3	5445	3800	3720
2	21070	20220	20710
Total Length	37560	37560	34970

*Under Option 1 the Mark West Development is not included in the system. Under Option 2 it is included.

Tests of the production well drilled in 1983 (CD-3) indicate that it will sustain over 1000 gpm pumping rate (Ghusn, 1983) which is more than the required peak flow under Option 1. It will, however, be necessary to drill another well in the production area for backup. It is assumed that this well will be identical to CD-3. Each well will be equipped with a turbine pump with variable speed drive. During peak requirements the load will be equally divided between the two wells. The required pump and motor sizes are then as follows:

	<u>Peak Flow/Pump</u>	<u>Pump Pressure</u>	<u>Pump Motor</u>
Option 1	477 gpm	93 psi	40 hp
Option 2	681 gpm	87 psi	55 hp

One injection well will be drilled to return the used geothermal fluid to the aquifer as required by the state of Nevada, Division of Water Resources (permit dated April 19, 1984). The injection well will be identical to the production well. An injection pump will not be required as the small injection pressure needed will be supplied by the production pumps. Under Option 1 the injection well will be located west of the city as indicated in Drawing No. 1. Under Option 2 the location will be downstream from the Mark West Development, about five miles west of the city.

Space heating will be accomplished by finned tube coils in existing forced air ducting where possible. Other areas will require unit forced air convectors. It is assumed that the geothermal water is potable without chlorination. This allows hot tap water to be furnished directly from the geothermal distribution system without heat exchangers.

It is assumed that 50% of users will be connected to the district heating system at start up. The remaining buildings in town including

new additions will be connected over a period of three years from start up. It is assumed that energy demand in Caliente will grow at a rate of 1% per year over the 20 year projected life of the district heating system. This growth rate is shown in Figure 4.

Estimated annual water usage by the district heating system based on the present size of the city of Caliente is about 221 acre feet with 179 acre feet injected. When the system is operated at design conditions (i.e. during the 20th year) the annual usage is 269 acre feet with 218 acre feet injected. Total geothermal water usage during the 20 year project life is estimated to be 4620 acre feet.

CAPITAL AND OPERATING COSTS

Estimated capital and operating costs are summarized in Table X. The total capital cost is estimated to be 3.14 million dollars if Option 1 is chosen but increases to 4.23 million dollars under Option 2. In both options an estimated \$600,000 is included to retrofit the existing buildings in the city. The main difference in the cost of the two options is to be found in the distribution system for the following two reasons:

1. The return pipes are uninsulated PVC pipe when Option 1 is chosen whereas Option 2 calls for insulated FRP return pipe.
2. The additional water which the distribution system must carry under Option 2 requires a larger diameter main supply line through the city.

The operating cost for the first year is estimated to be \$80,225 for Option 1 and \$97,170 for Option 2. The assumption that only 50% of the existing buildings in the city are on line at start up is reflected in the reduced cost of electricity for pumping and convactor fans. Other

FIGURE 4. District heating system peak demand.

operating cost items are assumed to be unaffected by the system load.

TABLE X
Capital and Cost Estimates for District Heating
System in Caliente

	<u>Option 1</u>	<u>Option 2</u>
A. <u>Capital Cost</u>		
Drilling two wells (production & injection)	12,000	12,000
Two downhole turbine pumps w/drives	92,000	98,000
Distribution piping system	1,800,000	2,690,000
Wellhead buildings	8,000	8,000
Retrofitting existing buildings	600,000	600,000
Miscellaneous electrical and mechanical	90,000	90,000
Engineering at 10%	<u>260,000</u>	<u>350,000</u>
Subtotal	2,862,000	3,848,000
Contingency	<u>278,000</u>	<u>382,000</u>
TOTAL CAPITAL COST	3,140,000	4,230,000
B. <u>Operating Cost</u>		
Maintenance:		
Piping	9,875	14,785
Equipment, buildings	46,600	50,920
Electricity:		
Pumping	3,215	4,390
Convactor fans	1,765	1,765
Insurance	<u>18,770</u>	<u>25,310</u>
TOTAL ANNUAL OPERATING COST	80,225	97,170

ECONOMIC ANALYSIS

Table XI shows the first year savings in electricity and heating fuel assuming that 50% of the users are connected. The savings during this year amount to \$200,750. The cost of electricity for pumping the geothermal water is not considered in this figure, but it is included as an annual operating cost.

In order to arrive at cost figures over the 20 year assumed life of the proposed district heating system, some assumptions must be made of rates of population increase and inflation and price escalation of operating cost items. For this analysis the following assumptions are made:

- a) Population in Caliente increases at a rate of 1.0% per year.
- b) Insurance cost and firewood prices follow the general inflation rate.

For general inflation and fuel price escalation the forecasts recently prepared by the Washington State Energy Office (WSEO, March 1984) are used. These are as follows:

<u>Year</u>	<u>General Inflation</u>	<u>Gas and Fuel Oil</u>	<u>Electricity</u>
1984	1.000	1.000	1.000
1985	1.042	1.032	1.062
1986	1.092	1.082	1.113
1987	1.150	1.150	1.194
1988-2000	6% per year	7% per year	6.5% per year
2001-2020	6% per year	8% per year	6% per year

The projected conventional heating cost and savings with geothermal district heating in Caliente over the 20 year period are shown in Tables XII a and b for the two options, 1 and 2. In preparing this table it has been assumed that heating habits in the town will remain the same

TABLE XI
Energy Savings at Start Up of District Heating System, Caliente

		Electricity	Fuel Oil	Propane	Wood	Total
Total energy usage for space heat and hot water, MWh/year	Commercial	934	1,000	1,000	-	2,934
	Industrial	905	452	164	-	1,521
	Residential	3,512	520	293	1,698	6,023
	Total	5,351	1,972	1,457	1,698	10,478
Unit of Measurement		kWh	gal.	gal.	cord	
Price, \$/unit	Comm. & Ind.	0.035	1.038	0.839	40.00	-
	Residential	0.035	1.038	0.949	40.00	-
Heating value	Btu/unit	3,413	140,000	90,000	12 x 10 ⁶	-
	kWh/unit	1.00	41.0	26.4	3,516	-
Combustion Efficiency, %		100	65	65	30	-
Energy cost /kWh output	Comm. & Ind.	0.035	0.0389	0.0489	0.0379	-
	Residential	0.035	0.0389	0.0554	0.0379	-
Estimated heating cost, \$/year		187,285	76,710	73,150	64,355	401,500
Estimated savings, 50%, \$/year		93,643	38,355	36,575	32,177	200,750

as they are today and that the percentages of heating energy derived from the various energy sources; electricity, fuel oil, propane and firewood are unchanged.

The total savings with the proposed district heating system in Caliente are shown in the last four columns of Tables XII a and b. The cumulative cash flow for Option 1, third column from the right in Table XII a, shows that simple payback is obtained in less than eight years. Discounted savings based on an assumed financing of the project at 12% annual rate of interest are shown in the last two columns of the table. The cumulative discounted cash flow over the 20 year period comes to \$4,073,856 which is considerably more than the capital cost estimate for the geothermal system, \$3,140,000 (Option 1). This indicates that the project will do more than pay for itself over the 20 year period based on conventional fuel rates.

This result shows that the rates charged for the geothermal district heating can be reduced considerably below the cost of conventional fuel heating. This should provide for some incentive for the consumers to switch from conventional fuel to the geothermal system. An average rate of about 75 to 80% of conventional heating cost should be sufficient.

The last two columns of Table XII b show the discounted savings for Option 2 based as before on estimated conventional fuel heating costs in Caliente. The cumulative discounted cash flow over the 20 year period amounts to \$3,864,018 which is close to nine percent under the estimated capital cost of \$4,230,000 for this option. Since, however, the requirements for the geothermal water in the Mark West Development are unknown, an evaluation of the economic feasibility of Option 2 cannot be made at this time.

TABLE XII a
Conventional Heating Cost and Savings with Geothermal District Heating, Caliente
Option 1

	Heating Oil Present System	Propane Present System	Firewood Present System	Electricity Present System	Electricity Geothermal System	Insurance Geothermal System	Maint. Geothermal System	Net Energy Savings Cash Flow	Cumulative Cash Flow	Discounted Cash Flow	Cumulative Discounted Cash Flow
Year zero cost	38355	36575	32177	93643	4980	18770	56475				
Year											
1984	50368	48030	42663	126549	6730	19558	58847	182475	182475	162925	162925
1985	67201	64082	56896	168766	8975	20497	61672	265801	448276	211895	374819
1986	90882	86665	76246	230382	12252	21586	64946	385392	833668	274314	649134
1987	98216	93658	81629	247822	13179	22881	68843	416423	1250091	264645	913778
1988	106142	101217	87392	266582	14177	24254	72974	449930	1700021	255302	1169080
1989	114708	109385	93562	286763	15250	25709	77352	486107	2186128	246277	1415357
1990	123965	118212	100168	308471	16405	27251	81993	525167	2711294	237559	1652916
1991	133969	127752	107240	331822	17647	28886	86913	567337	3278631	229138	1882054
1992	144780	138061	114811	356941	18982	30619	92128	612864	3891495	221005	2103058
1993	156464	149203	122916	383961	20419	32457	97655	662014	4553509	213151	2316209
1994	169091	161244	131594	413027	21965	34404	103515	715072	5268581	205566	2521775
1995	182737	174256	140885	444293	23628	36468	109726	772349	6040930	198243	2720018
1996	197483	188318	150831	477926	25416	38656	116309	834178	6875107	191172	2911190
1997	213420	203516	161480	514105	27340	40976	123288	900917	7776025	184346	3095535
1998	230643	219939	172880	553023	29410	43434	130685	972957	8748982	177756	3273291
1999	249256	237689	185086	594887	31637	46040	138526	1050715	9799696	171394	3444685
2000	271889	259271	198153	636886	33870	48803	146837	1136688	10936384	165552	3610238
2001	296576	282812	212143	681850	36261	51731	155648	1229741	12166126	159915	3770153
2002	323505	308492	227120	729989	38821	54835	164987	1330463	13496588	154476	3924628
2003	352880	336503	243154	781526	41562	58125	174886	1439490	14936078	149227	4073856
Total	3574177	3408304	2706851	8535573	453928	707171	2127728	14936078		4073856	

Simple Payback 7.76
Discounted Payback 14.25

TABLE XII b

Conventional Heating Cost and Savings with Geothermal District Heating, Caliente
Option 2

	Heating Oil Present System	Propane Present System	Firewood Present System	Electricity Present System	Electricity Geothermal System	Insurance Geothermal System	Maint. Geothermal System	Net Energy Savings Cash Flow	Cumulative Cash Flow	Discounted Cash Flow	Cumulative Discounted Cash Flow
Year zero cost	38355	36575	32177	93643	6155	25310	65705				
Year											
1984	50368	48030	42663	126549	8318	26373	68465	164455	164455	146835	146835
1985	67201	64082	56896	168766	11093	27639	71751	246462	410917	196478	343313
1986	90882	86665	76246	230382	15143	29107	75561	364365	775283	259348	602661
1987	98216	93658	81629	247822	16289	30853	80095	394090	1169373	250451	853113
1988	106142	101217	87392	266582	17522	32704	84900	426208	1595580	241842	1094954
1989	114708	109385	93562	286763	18848	34666	89994	460909	2056489	233511	1328465
1990	123965	118212	100168	308471	20275	36746	95394	498400	2554890	225451	1553916
1991	133969	127752	107240	331822	21810	38951	101118	538904	3093793	217654	1771570
1992	144780	138061	114811	356941	23461	41288	107185	582660	3676453	210113	1981683
1993	156464	149203	122916	383961	25237	43765	113616	629927	4306379	202819	2184503
1994	169091	161244	131594	413027	27148	46391	120433	680984	4987364	195767	2380269
1995	182737	174256	140885	444293	29203	49175	127659	736135	5723498	188947	2569217
1996	197483	188318	150831	477926	31413	52125	135318	795703	6519201	182355	2751571
1997	213420	203516	161480	514105	33791	55253	143437	860040	7379241	175981	2927552
1998	230643	219939	172880	553023	36349	58568	152043	929526	8308767	169821	3097373
1999	249256	237689	185086	594887	39101	62082	161166	1004569	9313335	163867	3261240
2000	271889	259271	198153	636886	41861	65807	170836	1087694	10401029	158416	3419657
2001	296576	282812	212143	681850	44817	69756	181086	1177723	11578752	153151	3572807
2002	323505	308492	227120	729989	47981	73941	191951	1275233	12853984	148063	3720870
2003	352880	336503	243154	781526	51368	78377	203468	1380849	14234833	143148	3864018
Total	3574177	3408304	2706851	8535573	561029	953569	2475474	14234833		3864018	

Simple Payback
Discounted Payback

9.88
NA

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