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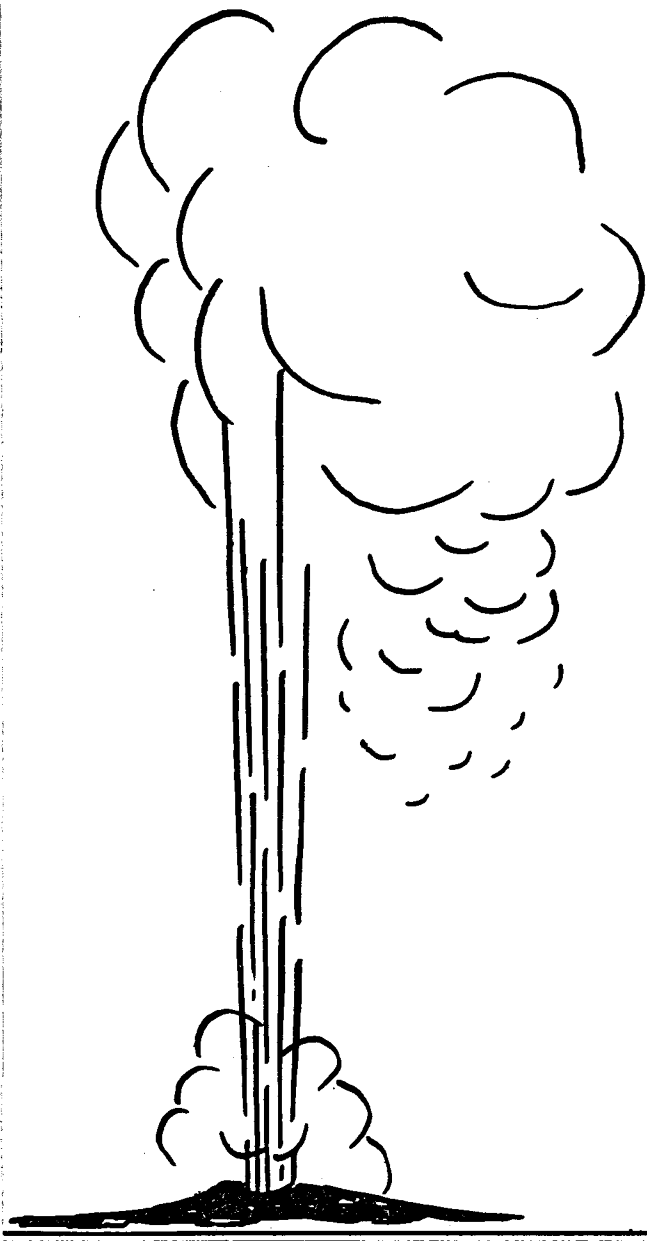

ADDITIONAL STUDIES OF GEOTHERMAL DISTRICT HEATING FOR MAMMOTH LAKES VILLAGE, CALIFORNIA

Final Report for October 1977—March 1978

By
Anker V. Sims
W. C. Racine

Work Performed Under Contract No. EY-76-C-03-1316

The Ben Holt Co.
Pasadena, California

U. S. DEPARTMENT OF ENERGY

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Anker V. Sims
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PREPARED FOR THE
DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY
UNDER CONTRACT NO. EY-76-C-03-1316

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INTRODUCTION

Mammoth Lakes Village is a winter and summer recreational resort located in the eastern Sierra Nevada Mountains of California at an elevation of 8,000 feet. About eighty-five percent of space and water heating demands for up to 17,000 Village visitors are now provided by electric resistance heating. Utilization of such a highly refined energy resource as electrical energy for heating suggests that alternative energy sources be examined.

Magma Energy, Inc. owns a geothermal resource on a 90 acre parcel at Casa Diablo Hot Springs, about three miles east of Mammoth. Eight geothermal wells were drilled on this property in the years 1959 to 1962. The wells have produced fluid with temperatures in excess of 340°F.

A report prepared in December, 1977 (SAN/1316-4) presented the results of a one-year study to determine the technical, economic and environmental feasibility of utilizing the Casa Diablo geothermal resource for heating in Mammoth Lakes Village. The concept studied was to heat a fresh water loop with geothermal brine, circulate the fresh water to the Village where it would provide space and water heating energy via hydronic heaters located in individual buildings, and return the fresh water to the geothermal area for reheating and reuse.

The report concluded that geothermal district space and water heating is feasible for Mammoth Lakes. The annual heating costs using geothermal energy were shown to be higher than with conventional heating systems when the District Heating System is first installed. However, after a maximum of six years of operation, geothermal district heating can provide less costly space and water heating for all buildings investigated.

Based upon the favorable results of the above feasibility study, three additional tasks were undertaken. The first was to determine the effects on district heating energy costs if swimming pool, jacuzzi pool and snow melting loads were served in addition to space and water heating. The second additional task was to determine the permitting requirements which would need to be met before a geothermal District Heating System could be constructed and operated at Mammoth. The third additional task was to prepare a schedule for design and construction of a District Heating System.

The Ben Holt Co. was the prime contractor for this study. Holt was assisted by Southern California Edison Company (SCE), Ayres Associates (Ayres) and Magma Energy, Inc. (Magma).

SUMMARY

A field survey of three heating uses: snow melting, jacuzzi pool heating, and swimming pool heating in Mammoth was undertaken. Based on the results, monthly heating capacity factors were calculated and rough designs were prepared for hydronic district heating for each system. Capital cost estimates were prepared for snow melting, jacuzzi pool heating and swimming pool heating systems using LPG and geothermal district heating.

It was determined that incorporation of the three additional heating uses in the District Heating System previously defined would require a capacity increase from 52 MWt to 60 MWt to meet peak demands. Energy sales would increase by about 40 percent to 127 million kwh(t) per year. The unit cost for delivered heat at 1977 price levels would decrease from 4.26¢ to 3.22¢/kwh(t) for an investor owned District Heating System, or from 2.89¢ to 2.24¢/kwh(t) for public ownership.

The total heating costs, including annual costs of customer's heating equipment for a typical building in the Village with district heating, were compared with costs to heat the same building with electricity. For all buildings studied, hydronic space and water heating using a 60 MWt nonprofit owned District Heating System is less costly to the user than electric heating. For investor ownership, district heating provides less costly heating after two to four years, depending upon the building under consideration.

The total annual costs for snow melting, jacuzzi heating and swimming pool heating using a 60 MWt District Heating System were compared with costs to heat with LPG. Jacuzzi and swimming pool heating is less costly to the user than LPG heating, assuming nonprofit ownership of the District Heating System. With investor ownership of the system, hydronic heating becomes less costly after three years of operation. Hydronic snow melting using district heating is less costly than an LPG heating system after two or five years of operation, depending on system ownership.

It was determined that 11 permits must be obtained prior to beginning construction of the District Heating System. The longest permit lead time is 49 months for the U.S. Forest Service Special Use Permit. All other permits will require 21 months or less to obtain.

A project schedule outlining regulatory, engineering, design, construction and operation activities for the District Heating System was prepared. For this schedule it was assumed that the long lead time of 49 months for the U.S. Forest Service Permit can be reduced to 24 months. Assuming environmental data collection can begin by mid-1978, and project participants can be identified by fall, 1978, the District Heating System could be operational by the winter of 1982-83.

The economic analysis presented in this report demonstrates that significant cost reductions can be achieved by expanding and diversifying the use of heating energy. Diversification improves the capacity factor because additional loads can be handled by the facilities with little or no expansion required to cover peak demands.

The prospects of lower costs would invite new uses of heat energy such as snow melting (a few existing snow melting facilities are not in use because of high energy costs) and increased application of peak heating. This provides a strong incentive to pursue the expanded heating project. As a preliminary, it is recommended that long term reservoir data be obtained as described in SAN/1316-4 (page 41). Such data are required before a large scale heating plant can be built on the site.

ADDITIONAL HEATING LOADS

Department of Energy report SAN/1316-4 entitled "Feasibility of Geothermal Space/Water Heating for Mammoth Lakes Village, California" concluded that space and water heating using a 52 MWt geothermal District Heating System will initially result in building heating costs in excess of conventional sources of heating energy. The report also concluded that the geothermal District Heating System will result in lower heating costs than conventional energy sources for typical buildings after a maximum of six years of system operation.

Although the economics are favorable, they are not compelling to possible investors. It was, therefore, considered appropriate to determine if additional uses of heat could improve the economics of district heating by improving the system capacity factor. The uses investigated include snow melting and jacuzzi and swimming pool heating.

A. FIELD SURVEY

A field survey was conducted to gather data to establish the energy usage of swimming pools, jacuzzi pools and snow melting installations that are presently operating in Mammoth Lakes Village. It would be preferred to use data obtained from actual utility bills for the surveyed installations. However, these data could not give the desired information, because the installations are combined with other uses on the same meter and their energy use could not be segregated. In the case of snow melting installations, almost all had been shut down because of high utility costs. Data were, therefore, compiled on the size of the installations, the capacity of the heating equipment and the operating modes, so that average hourly heat consumption and capacity factors could be calculated.

Three swimming pools were surveyed at two condominiums and a motel. They were all very similar in size and operation and were reported to be representative of typical outdoor pools in the Village. The average pool size (560 ft^2) and LPG heater size (475,000 Btu/hr) were used for the heat calculations. The pools are heated to 85°F during the summer months only, and water circulated without heat to keep them from freezing in the winter.

Seven jacuzzi pools were surveyed at motels and condominiums. They varied in size and protection from the elements, but the operation of all the pools was the same. The average pool size (100 ft^2) and LPG heater size (200,000 Btu/hr) were determined from the survey data and used for the heat calculations. The typical pool is protected by a roof, but the area is open at the sides. The jacuzzi pools operate all year around and are kept at 105°F in winter and 90°F in summer. In winter the pools are used only from 3 p.m. to 10 p.m. and are covered when not in use.

Three snow melting installations were surveyed at two commercial buildings and a motel, two electric, and one hydronic. However, based on interviews with contractors and owners it was determined that these installations are not representative of the typical system at the Village. The installation that is typical of the largest number of snow melting systems would be a driveway for a condominium. No such system is presently operating because of prohibitively high utility costs, estimated to be about $900 per year per 1,000 ft^2 of electric snow melting. Data were, therefore, obtained from the installing contractor and used for the heat calculations. The systems are manually controlled to operate whenever it snows and the installed heating capacity is 60 watts per square foot.

B. MONTHLY ENERGY USE

In order to determine the relationship of the additional loads to the load shape for space and water heating presented in the SAN/1316-4 report, monthly energy use calculations were prepared for the additional loads.

The average hourly use of energy for a typical swimming pool was calculated for each of the summer months and then compared to the available heater capacity to obtain a capacity factor for each month. The heat loss due to evaporation was calculated based on the monthly mean dew point temperature from Bishop Airport weather data. The listed mean dew point temperature was reduced by 10 percent to compensate for the higher elevation at Mammoth Lakes Village. The heat loss due to conduction was calculated based on the monthly average temperature at the Bishop Airport. The average temperature was also reduced 10 percent to compensate for the elevation difference. The total heat loss was divided by the available heater output capacity to give a monthly capacity factor for the swimming pool. The results are shown in Table 1.

The average hourly use of energy for a typical jacuzzi pool was calculated for the summer months by the same method as for the swimming pool. In order to account for warm-up loads during winter, the capacity factors for the winter months were assumed to be equal to the fraction of time in which the jacuzzi pool is in use. Monthly capacity factors are shown in Table 1.

The snow melting energy usage for a 1,000 square foot system was calculated for each of the winter months based on average monthly snowfall. The number of hours of snowfall per month was determined from the average yearly snowfall at Lake Mary, the closest location from which data are available. The snowfall was then proportioned between the winter months using Bishop Airport mean monthly total snow data. The calculated capacity factors are tabulated below.

TABLE 1

MONTHLY HEATING CAPACITY FACTORS
ADDITIONAL HEATING LOADS

Heating Capacity	Heating Use: Swimming Pool 139 Kwt/pool	Jacuzzi Pool 59 Kwt/pool	Snow Melting 60 Kwt/1,000 ft^2
January	-	.29	0.13
February	-	.29	0.06
March	-	.29	0.03
April	-	.29	0.02
May	-	.08	0.03
June	.15	.08	-
July	.14	.08	-
August	.13	.08	-
September	-	.08	-
October	-	.08	-
November	-	.29	0.06
December	-	.29	0.04

These capacity factors were used to determine the average monthly load in the Village for each additional use. It is assumed that each motel and each condominium complex using the District Heating System for space and water heating in 1988 would be a candidate for jacuzzi heating and swimming pool heating. The SAN/1316-4 report was based on serving 162 condominium complexes and 44 motels, giving a total of 206 candidate buildings for pools.

It is further assumed that each of the above buildings would have 2,000 ft^2 of snow melting area. In addition, there would be 273 commercial buildings and homes with an average of 500 ft^2 snow melting area and 26 restaurants with an average 1,000 ft^2 snow melting area. The total potential snow melting area for the Village is then 575,000 ft^2.

Based on the above data and assumptions the average monthly loads for the Village were calculated as shown in Table 2.

TABLE 2

AVERAGE MONTHLY LOADS
ADDITIONAL HEATING LOADS
(MWt)

Month	Heating Use				Total
	Swimming Pools 206 Pools	Jacuzzi Pools 206 Pools	Snow Melting 575,000 ft^2	Space/Water	
January	-	3.5	4.5	19	27.0
February	-	3.5	2.1	21	26.6
March	-	3.5	1.0	20	24.5
April	-	3.5	0.7	14	18.2
May	-	1.0	0.1	9	10.1
June	4.3	1.0	-	6	11.3
July	4.0	1.0	-	4	9.0
August	3.7	1.0	-	3	7.7
September	-	1.0	-	3	4.0
October	-	1.0	-	6	7.0
November	-	3.5	0.2	7	10.7
December	-	3.5	1.4	13	17.9
Average	1.00	2.25	0.83	10.4	14.5
Annual Use, 10^6 Kwh/yr	8.8	19.7	7.3	91.1	127

The total average annual load is 14.5 MWt as compared with 10.4 MWt for district heating only.

C. CAPACITY OF NEW HEATING SYSTEM

The average monthly loads for all heating uses are plotted in Figure 1. The load for jacuzzi and snow melting closely parallels the load for space heating, and the seasonal load changes are improved only by adding the swimming pool load.

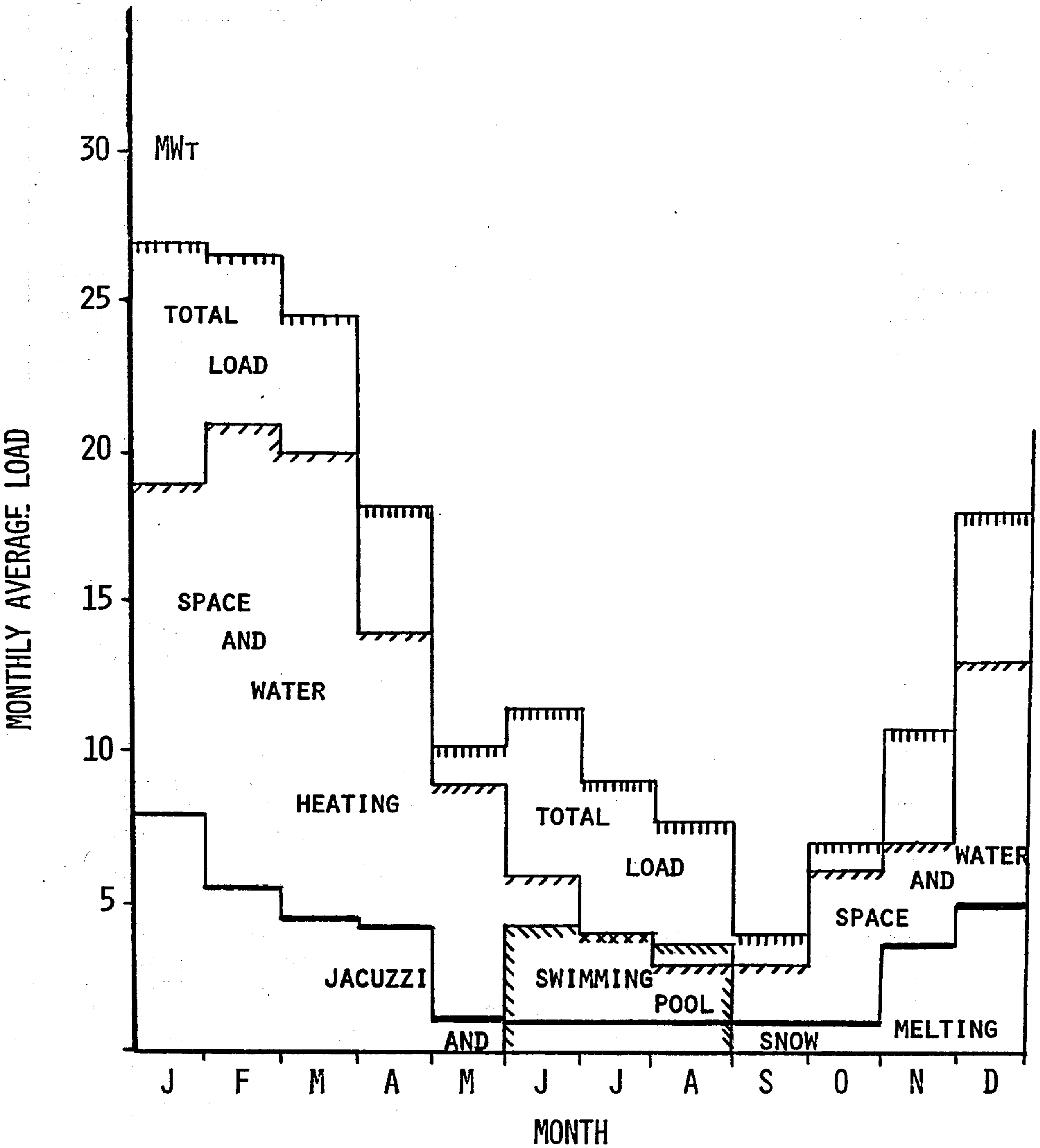
Even though the average monthly loads for jacuzzi/snow melting and space heating are both maximum during winter it is highly improbable that peaks for the two systems occur simultaneously. Extreme colds rarely coincide with high snowfall and outdoor jacuzzi use. The brine facilities and the brine/fresh water heat exchanger, therefore, need not be designed to handle the combined peak load.

A reasonable basis for design would be to add the maximum monthly jacuzzi/snow melting load (about 8 MWt) to the space heating peak load of 52 MWt resulting in a capacity of 60 MWt. The capcity factor for all systems combined, thus, becomes 14.5/60 = 24 percent as compared with 20 percent for the space heating system alone.

<u>FIGURE 1</u>

AVERAGE MONTHLY LOADS

<u>DISTRICT HEATING SYSTEM USES</u>



D. CAPITAL COST OF NEW HEATING SYSTEM

Brine flow from the wells would have to be increased by about 200,000 lbs/hr to deliver additional 8 MWt. The capital cost for well and brine piping would be increased by an estimated $500,000, including the cost of one new production well. Total capital cost of wells, pumps and brine piping would then be $2,800,000.

The fresh water delivery system to the Village consisting of storage tanks, main supply and return lines, area distribution supply and return lines and pumps can remain unchanged as designed for the 52 MWt space/water District Heating System; if the new assumed peak demand of 60 MWt can be met by using exit water from space/water heating at 140°F for snow melting and jacuzzi heating. The additional 8 MWt load at peak would then reduce the fresh water return temperature from 140°F to 132°F. Heaters for snow melting and jacuzzi heating have been designed for 140°F water, and the capital cost of the fresh water delivery system is, therefore, unchanged at $10,450,000.

The summer peak load for the space/water heating system is estimated at 10 MWt (water heating only). Adding the swimming pool peak demand of 29 MWt results in a total summer peak load of 39 MWt, which is well within the 60 MWt design capacity of the heating system. The total peak is also below the 52 MWt capacity of the hot water delivery system at 195°F; i.e., 195°F water can be used for all heating purposes in the summer months and the swimming pool heaters can be designed for 195°F feed water.

The heating plant (brine/fresh water heat exchanger) would have to be larger to handle the 60 MWt winter peak load, a 15 percent increase. The lower fresh water return temperature at winter peak load (132°F) increases the mean temperature difference by about 5 percent; and the size of the heating plant (surface) should, therefore, be increased by about 10 percent. This would add an estimated $100,000 to the capital cost of the heating plant, resulting in a new cost of $1,950,000.

The capital costs for the 60 MWt Geothermal District Heating System are recapitulated in Table 3.

TABLE 3

CAPITAL COST - GEOTHERMAL DISTRICT HEATING SYSTEM

	K$
Wells and Brine Handling	2,800
Brine/Fresh Water Heating Plant	1,950
Fresh Water Delivery System	10,450
TOTAL	15,200

E. ENERGY DELIVERY CHARGES

As in the SAN/1316-4 report, energy delivery charges are based upon two components of cost; a geothermal energy charge associated with providing geothermal energy to the Heating Plant, and an energy charge associated with the capital and operating costs of the District Heating System.

1. Geothermal Energy Charge

For calculation of the geothermal energy charge it was assumed that the developer of the geothermal wells will obtain a 15 percent rate of return after taxes based on discounted cash flow over 20 years; no depletion is allowed, and no royalty payment is required.

It is estimated that operating and maintenance costs will increase by $40,000 per year due to increased brine pumping and additional repairs.

Operating costs and geothermal energy charge for the expanded system are shown in Table 4. Costs are shown in 1977 dollars and the energy charge is escalated through year 10 assuming a 10 percent per year increase in operating and maintenance costs.

TABLE 4

OPERATING COSTS - WELLS AND BRINE FACILITIES

127×10^6 Kwht/yr	K$/yr
Operating and Maintenance	194
Property Taxes, 4%	112
Income Taxes (53%), calculated at 140 K$/yr depreciation (20 yr straight line)	347
15% Return after taxes	447
Geothermal Energy Charge	1,100
Year 1	0.87 ¢/Kwh(t)
2	0.90
5	0.95
7	0.99
10	1.04

The geothermal energy charges shown in Table 4, which incorporate additional heating uses, are about 10 percent to 12 percent lower than the costs reported in the SAN/1316-4 report for space and water heating uses only.

2. District Heating System Energy Charge

The energy charge associated with constructing, operating and maintaining the District Heating System was calculated assuming investor ownership (i.e., SCE) or public ownership (i.e., Mono County) of the system.

Due to increased pumping of fresh water to heat the swimming pools, it is estimated that operating and maintenance costs will increase by $20,000 per year. Capital cost annual carrying charges are calculated at 20 percent for investor ownership and 10 percent for public ownership.

Operating costs and energy charges for the District Heating System are shown in Table 5. Costs are shown in 1977 dollars and the district heating energy charge is escalated through year 10 assuming a 10 percent per year increase in operating and maintenance costs.

TABLE 5

OPERATING COSTS - DISTRICT HEATING SYSTEM

127×10^6 kwh/yr	K$/yr	
Operating and Maintenance	500	
Annual Carrying Charges	2,480 (investor owned)	
Annual Carrying Charges	1,240 (public owned)	
	Investor Owned	Public Owned
District Heating Energy Charge	2,980	1,740
Year 1	2.35¢/kwh(t)	1.37¢/kwh(t)
2	2.43	1.45
5	2.55	1.57
7	2.63	1.66
10	2.77	1.81

3. Total Energy Delivery Charges

The costs presented in Tables 4 and 5 were added to obtain a total cost of energy delivery to an average customer for both investor and public ownership of the District Heating System as shown in Table 6.

TABLE 6

TOTAL ENERGY DELIVERY CHARGE

Year	¢/kwh(t) Investor Ownership	¢/kwh(t) Public Ownership
1	3.22 (4.26)	2.24 (2.89)
2	3.33	2.35
5	3.50	2.52
7	3.62	2.65
10	3.81 (4.92)	2.85 (3.65)

The numbers in parantheses indicate the energy charges for a District Heating System serving space and water heating only (taken from the SAN/1316-4 report).

The total energy delivery charge for a system serving snow melting, jacuzzi heating and swimming pool heating in addition to space/water heating is significantly lower than for a system serving only space and water heating.

F. ANNUAL HEATING COSTS

The economic viability of the District Heating System is dependent upon the total annual cost that typical customers will be required to pay for district heating versus the annual cost to heat with LPG or electricity.

The customers' heating cost is the cost of energy plus the financial charges to pay for the installation of the heating equipment on the customer's property and the tie-in to the energy delivery system.

1. Annual Cost of Space/Water Heating

In the SAN/1316-4 report the installation costs of space/water heating equipment using geothermal energy were calculated for a number of typical customers, such as motels, condominiums and restaurants; and the annual financial charges were calculated on the basis of a 20-year building improvement loan at a 10 percent interest rate.

In order to determine the effects of incorporating additional heating loads on the total space/water heating costs two typical customers were selected: a 1,000 ft^2 condominium unit ("Season's Four") and a 16,000 ft^2 motel ("Wildwood Inn Motel"). It is assumed that heater installations are retrofits of existing facilities. The annual financial charges are added to the annual cost of delivered energy to give the customer's total annual heating cost as shown in Table 7.

TABLE 7

ANNUAL SPACE/WATER HEATING COSTS

	Condominium Unit		Motel	
Installed Capacity, kw	13.5(space) 4.5(water)		136(space) 152(water)	
Energy Use, kwh/yr	31,000		632,000	
Installation Cost	$2,700		$48,000	
Financial Charges	$320/yr		$4,700/yr	
Energy Costs	a	b	a	b
Year 1 ¢/kwh	3.22	2.24	3.22	2.24
Year 5 ¢/kwh	3.50	2.52	3.50	2.52
Year 10 ¢/kwh	3.81	2.85	3.81	2.85
Year 1 $/yr	1,000	690	20,400	14,200
Year 5 $/yr	1,090	780	22,100	15,900
Year 10 $/yr	1,180	880	24,100	18,000
Total Annual Costs				
Year 1 $/yr	1,320	1,010	26,100	19,900
Year 5 $/yr	1,410	1,100	27,800	21,600
Year 10 $/yr	1,500	1,200	29,800	23,700

NOTE a: District Heating System (Investor Owned)
b: District Heating System (Public Owned)

The total annual costs for hydronic space/water heating are plotted versus time assuming conversion to hydronic district heating in year 1. Figure 2 shows the condominium unit heating costs and Figure 3 shows the motel heating costs. The annual cost of electric heating is also shown. A 10 percent escalation is assumed for electric energy costs.

The dashed lines in Figures 2 and 3 represent the heating costs before the addition of pools and snow melting to the heating system. It is seen that the break-even point, after which time geothermal heating becomes less costly than electric heating, would occur two to three years earlier if the system is expanded to include the additional heating loads.

With public ownership of the District Heating System geothermal heating is less costly than electric heat already in the first year. With investor ownership the break-even point occurs in the third year.

FIGURE 2

ANNUAL HEATING COSTS
TYPICAL CONDOMINIUM - RETROFIT

NOTE:

——— FOR 60 MWT CAPACITY - 24% ANNUAL CAPACITY FACTOR

- - - - - FOR 52 MWT CAPACITY - 20% ANNUAL CAPACITY FACTOR

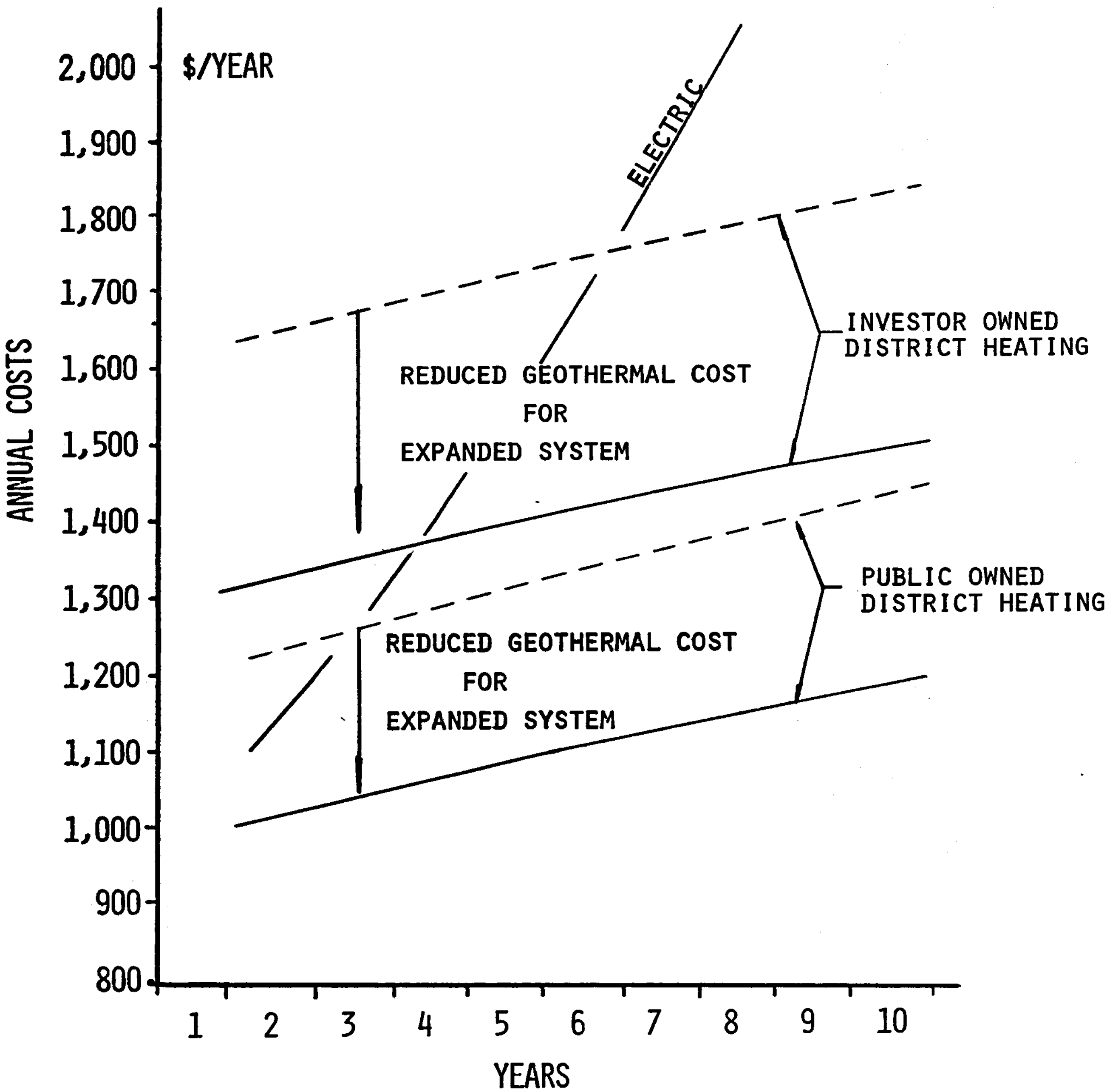
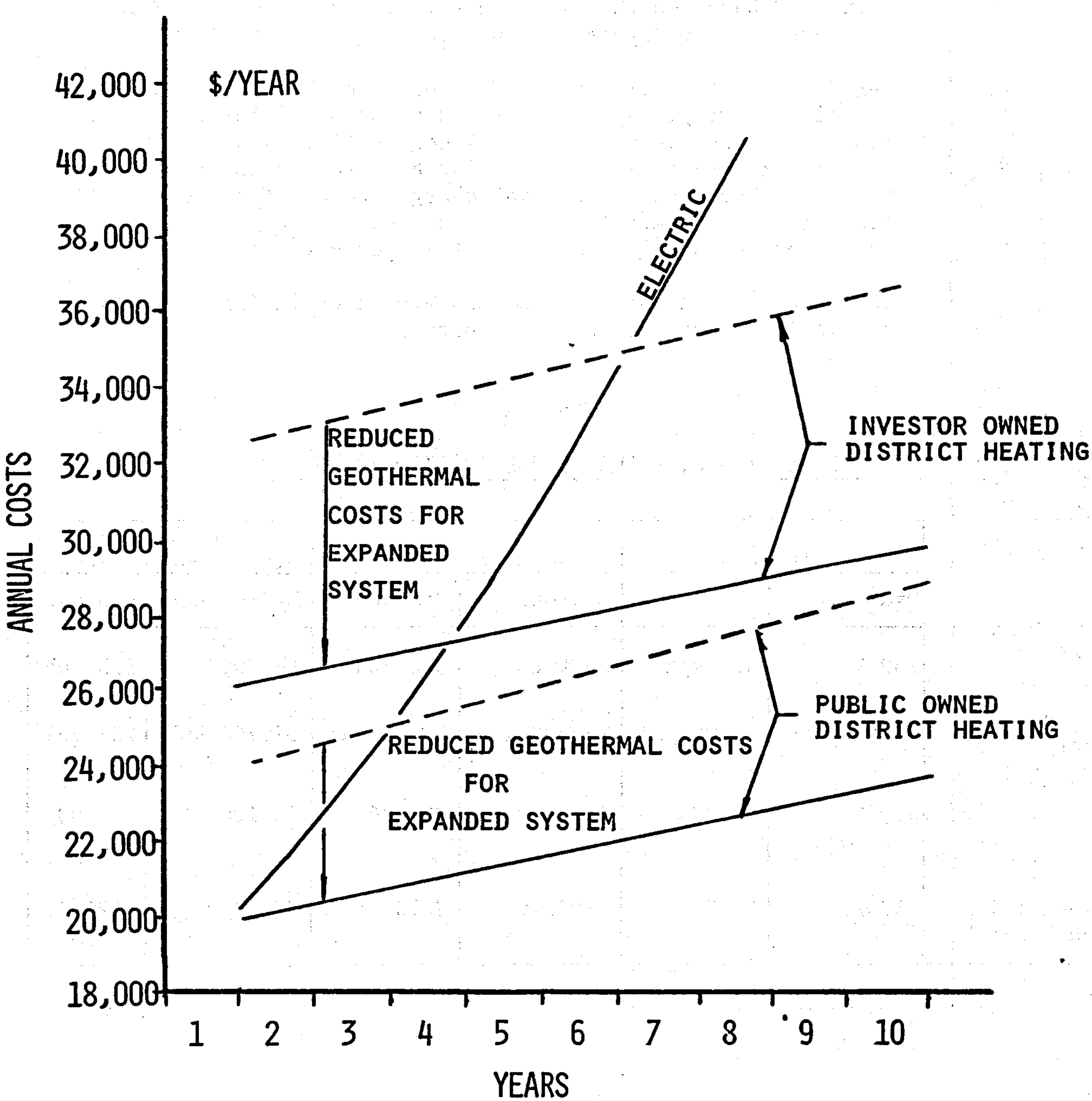


FIGURE 3

ANNUAL HEATING COSTS
TYPICAL MOTEL - RETROFIT

NOTE:
——— FOR 60 MWT CAPACITY - 24% ANNUAL CAPACITY FACTOR
– – – – FOR 52 MWT CAPACITY - 20% ANNUAL CAPACITY FACTOR



Analyses prepared for other typical buildings in the Village show similar results. For all buildings studied, hydronic space and water heating using a 60 MWt public owned District Heating System is less costly to the user than either electric or LPG heating. Hydronic space and water heating, using an investor owned District Heating System, provides less costly heating after two to four years, depending upon the building under consideration.

2. Annual Costs of Additional Heating Services

Annual financial charges for snow melting, swimming pool heating and jacuzzi pool heating were calculated for systems judged "typical" based on the field survey discussed above. Flow diagrams for each system are presented in Figures 4, 5 and 6.

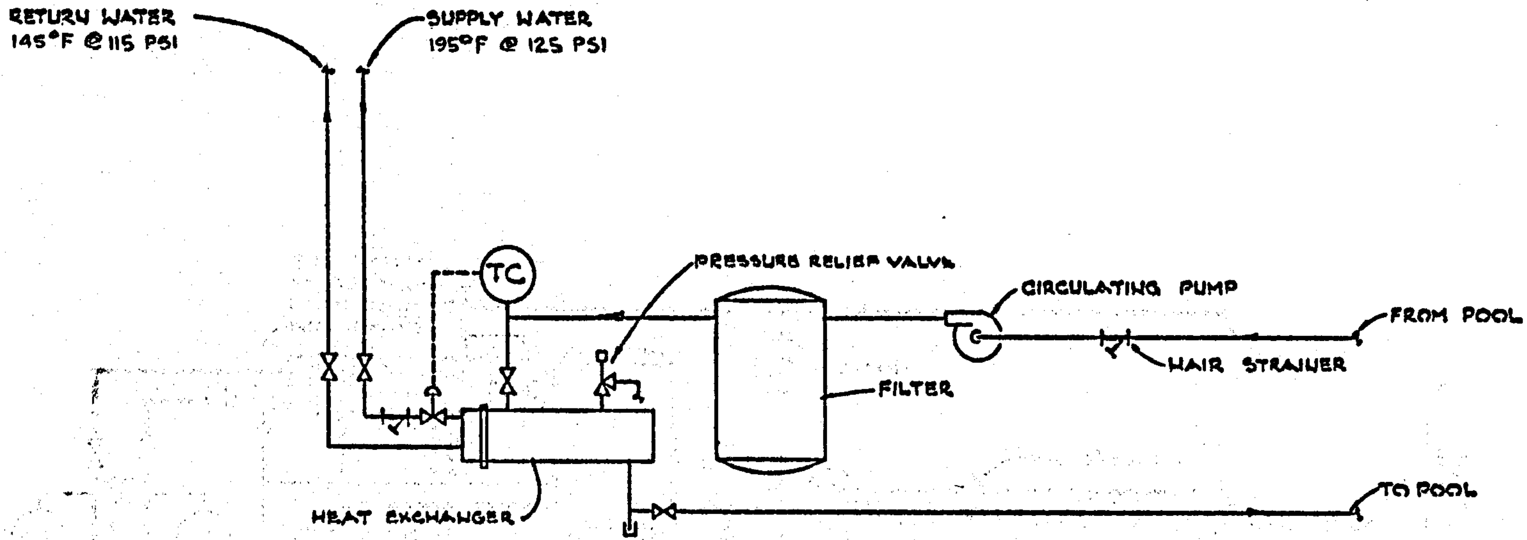
Based on the flow diagrams and layout sketches prepared during the field survey, capital costs were estimated for each additional heating concept. Capital cost estimates were also prepared for systems which provide heat to the additional uses via LPG. The annual financial charges to pay for the installation of the customers' heating equipment were calculated as above, based on a 20-year loan at 10 percent interest.

The results of these calculations are shown in Table 8. Installation costs are for new construction.

TABLE 8

ANNUAL FINANCIAL CHARGE FOR ADDITIONAL HEATING

	Swimming Pool		Jacuzzi Pool		Snow Melting ($1,000\ ft^2$)	
	Hydronic	Propane	Hydronic	Propane	Hydronic	Propane
Heating Capacity	139 kwt	8.5 gph	59 kwt	3.6 gph	60 kwt	3.5 gph
Annual Energy Use	43,000 kwh	2,600 gal	95,600 kwh	5,800 gal	12,700 kwh	735 gal
Heater Installation Cost	$3,200	$3,000	$3,300	$2,600	$6,100	$5,300
Annual Financial Charges	$380/yr	$350/yr	$390/yr	$310/yr	$724/yr	$620/yr



TYPICAL SWIMMING POOL HEATING FLOW DIAGRAM
195°F SUPPLY WATER

AYRES ASSOCIATES 1180 S. BEVERLY DR., LOS ANGELES, CA. 90035	CUSTOMER ERDA/MAMMOTH LAKES VILLAGE, CA/THE BEN HOLT COMPANY	DRAWN: GG DATE: 7-6-77	SHEET F- 4

FIGURE #4

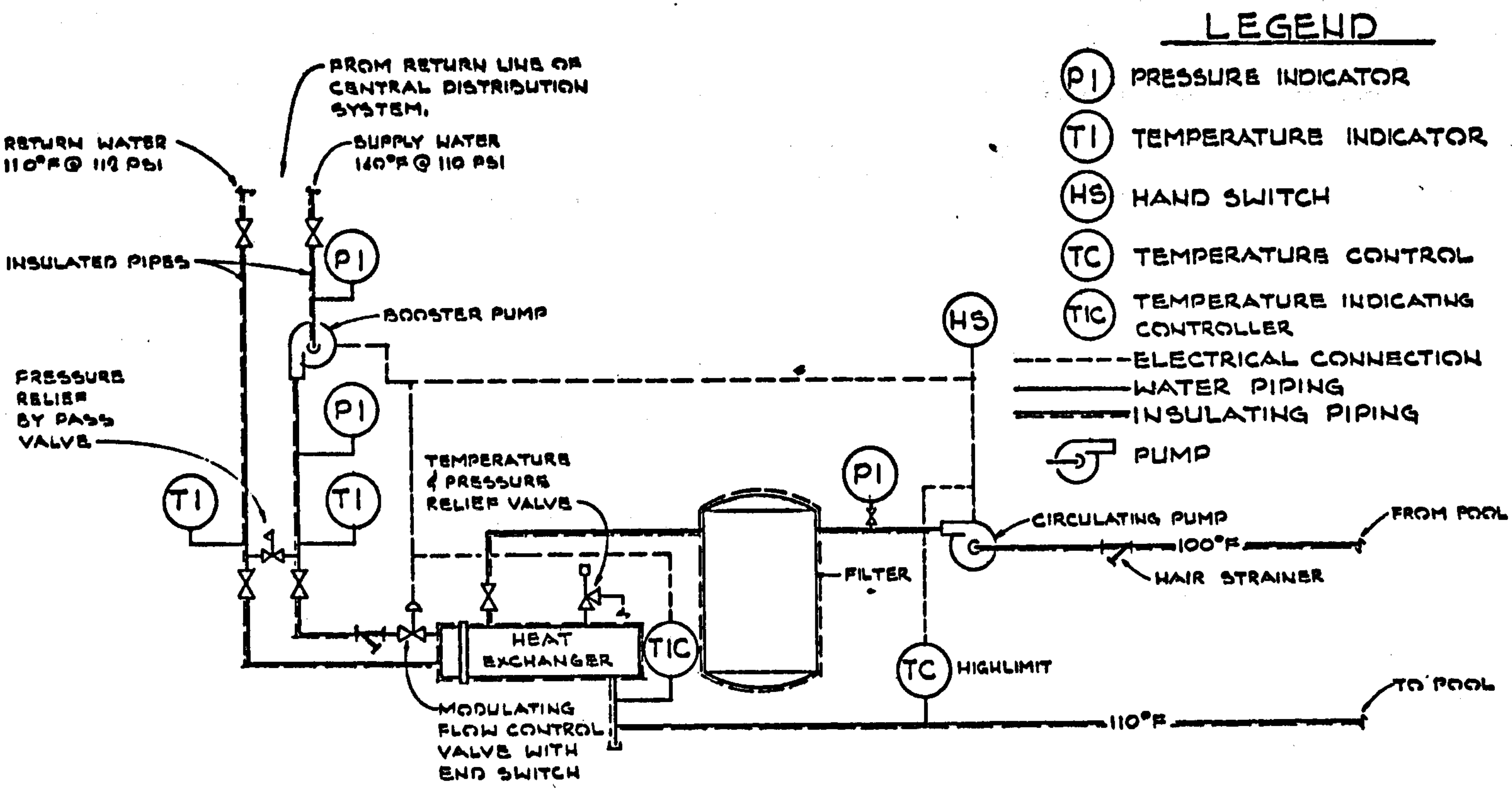


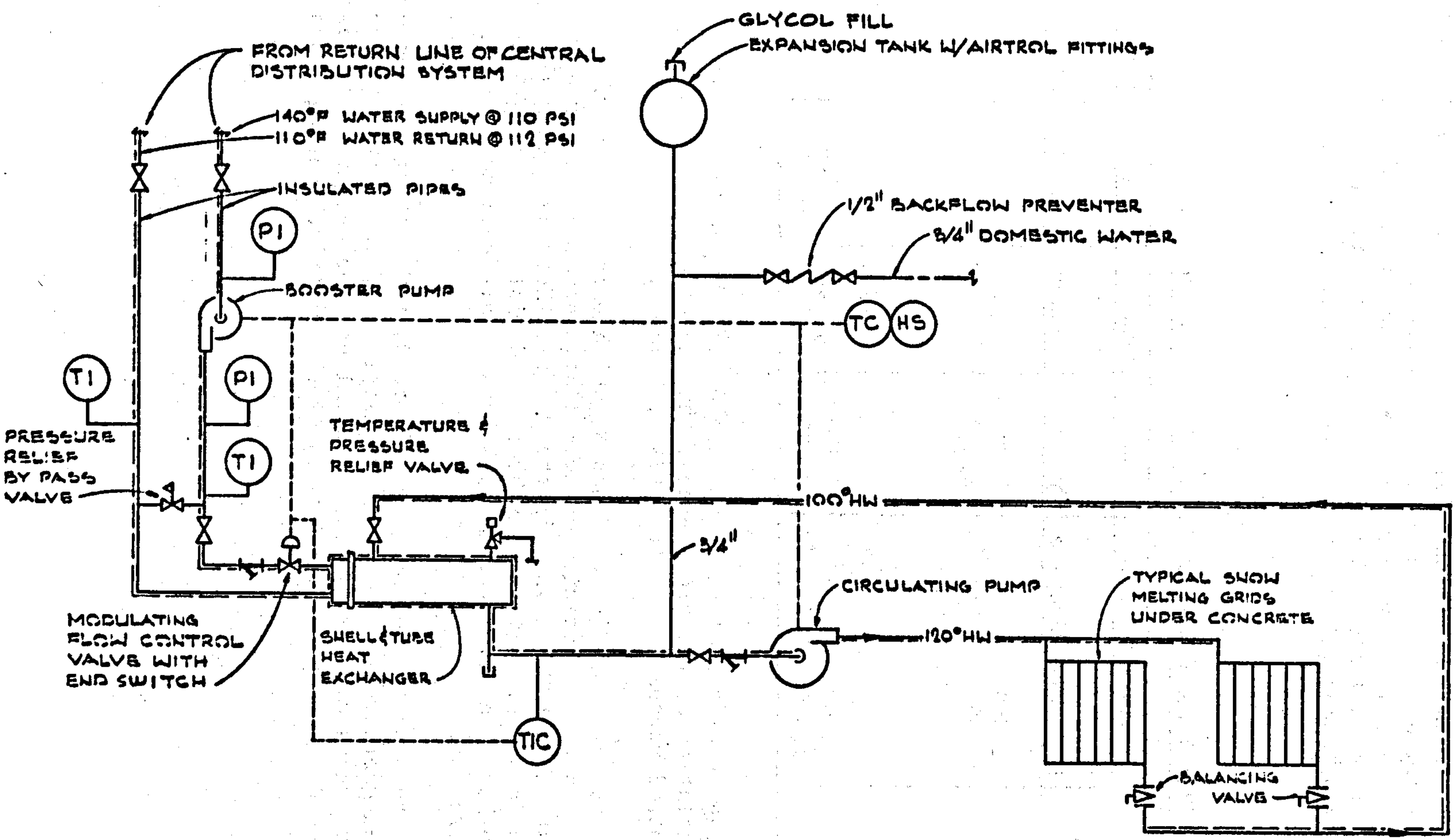
FIGURE # 5

18

TYPICAL JACUZZI POOL HEATING FLOW DIAGRAM
140°F TEMPERATURE SUPPLY WATER

AYRES ASSOCIATES 1180 S. BEVERLY DR., LOS ANGELES, CA. 90035	CUSTOMER DOE/ MAMMOTH LAKES VILLAGE CA/THE BEN HOLT COMPANY	DRAWN: CC DATE: 1-16-77	SHEET F-5

FIGURE # 6



TYPICAL SNOW MELTING FLOW DIAGRAM
140°F TEMPERATURE SUPPLY WATER

AYRES ASSOCIATES 1180 S. BEVERLY DR., LOS ANGELES, CA 90035	CUSTOMER DOE/MAMMOTH LAKES VILLAGE, CA/THE BEN HOLT COMPANY	DRAWN: CC DATE: 1-16-77	SHEET F-6

The annual costs to the customer for the heating of a swimming pool, a jacuzzi pool and 1,000 ft^2 of snow melting were obtained by adding the above financial charges to the geothermal energy costs calculated from the unit costs shown in Table 6. For propane a cost of 46 cents per gallon was used. The results are shown in Table 9 for the first year of operation for investor owned (a) and public owned (b) District Heating Systems.

TABLE 9

FIRST YEAR ANNUAL COSTS OF ADDITIONAL HEATING

	Swimming Pool		Jacuzzi Pool		Snow Melting	
Energy Costs, $/yr	Hydronic	Propane	Hydronic	Propane	Hydronic	Propane
a	1,380	1,200	3,080	2,670	410	340
b	960		2,140		280	
Total Annual Costs $/yr						
a	1,760	1,550	3,470	2,980	1,130	960
b	1,340		2,530		1,000	

Using escalated costs from Table 6, and 10 percent per year escalation of the propane cost the annual heating costs are plotted versus time in Figures 7, 8 and 9.

As indicated by Figures 7 and 8, which both represent the costs of pool heating, geothermal heating offers lower annual costs than LPG heating, if the District Heating System is public owned. With an investor owned District Heating System, geothermal heating becomes less costly after three years of operation.

In the case of snow melting (Figure 9) LPG heating is cheaper than geothermal heating in the first year; but, after two or five years of operation, geothermal heating becomes less costly depending on type of ownership of the District Heating System.

FIGURE 7

ANNUAL HEATING COSTS
TYPICAL SWIMMING POOL - NEW CONSTRUCTION

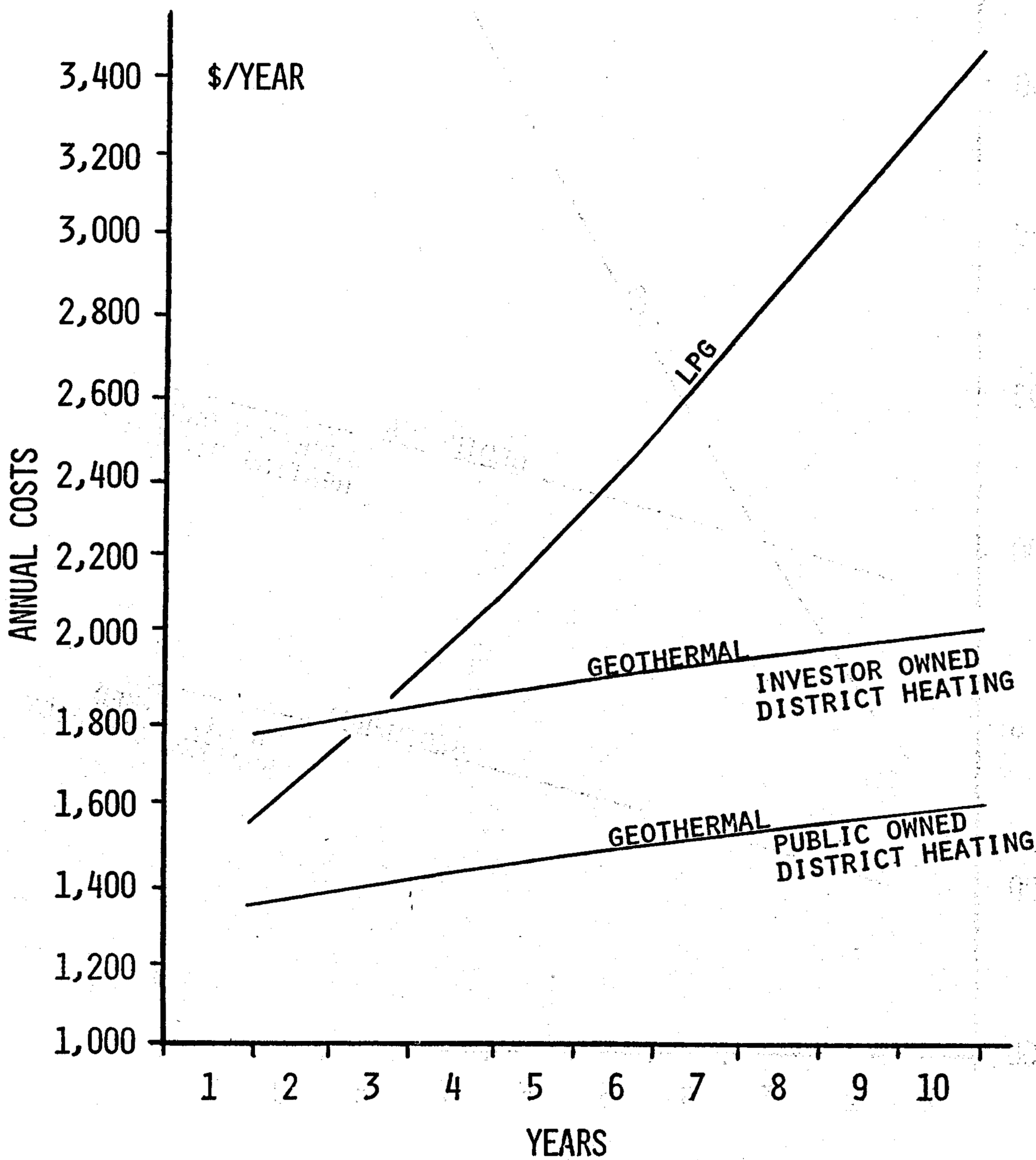


FIGURE 8

ANNUAL HEATING COSTS
TYPICAL JACUZZI POOL - NEW CONSTRUCTION

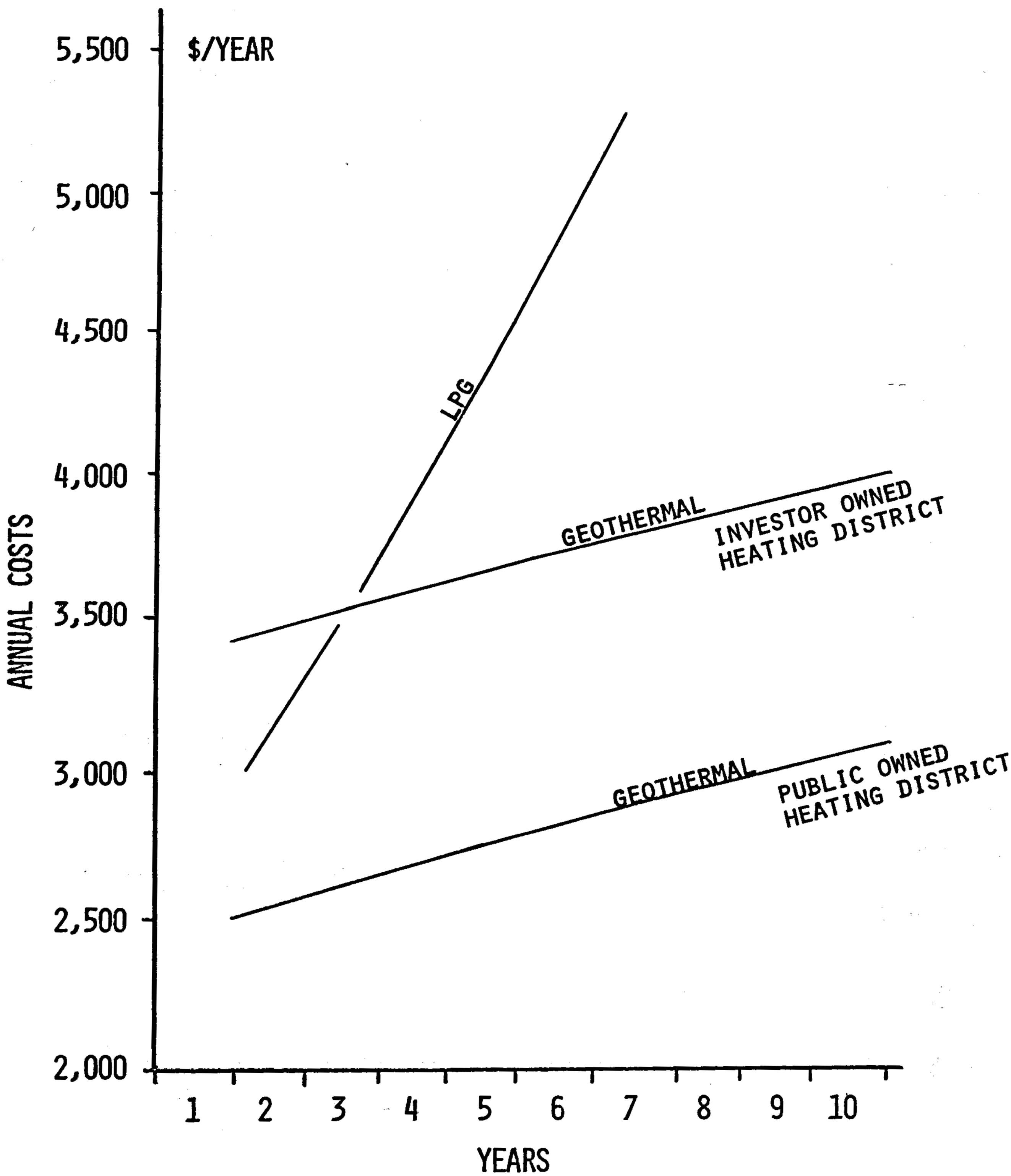
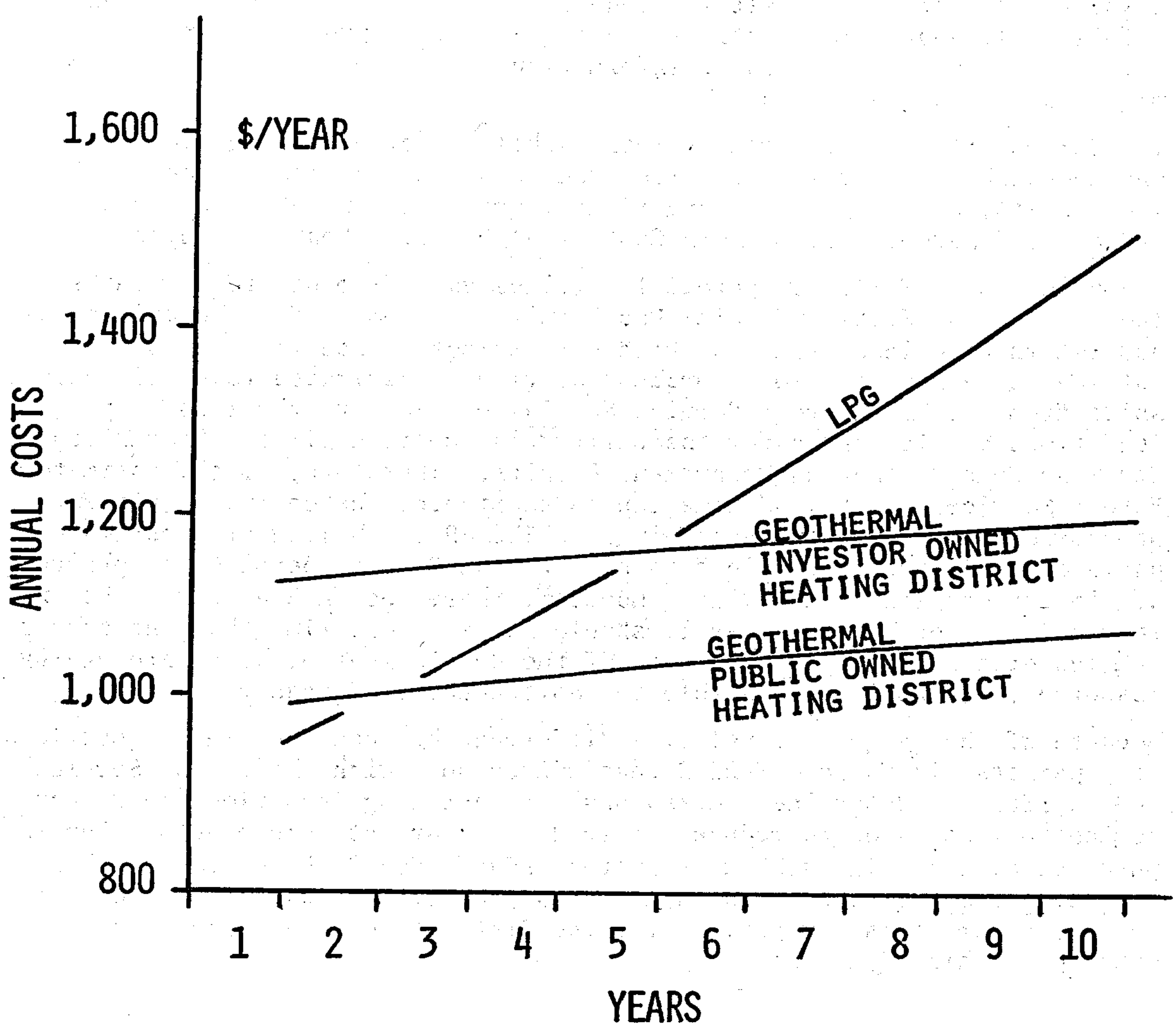


FIGURE 9

ANNUAL HEATING COSTS
SNOW MELTING (1,000 FT^2) - NEW CONSTRUCTION



REGULATORY REQUIREMENTS

An analysis of the permits which will be required before the proposed District Heating System can be constructed has been completed. The purpose of the analysis was to identify the regulatory agencies from whom permits or review procedures are required, and estimate the lead time for each permit. As permit lead times are often controlling in large projects such as the District Heating System, an early identification of permitting requirements is considered essential for proper project scheduling. Because of their experience in obtaining permits for large and complex projects, SCE prepared this analysis.

In order to determine which agencies would require permits for the system, two sources of information were employed. First, SCE's internal listing of permitting requirements for projects was reviewed, and those agencies which appeared to have jurisdiction over or interest in the District Heating System were identified. Second, Holt and SCE representatives attended a meeting of the Interagency Committee in Bishop, California. The Committee is composed of representatives of 25 local, state, and federal agencies with jurisdiction and/or operations in Inyo and Mono Counties. Project personnel presented an overview of the District Heating System design to the Committee. Agency representatives were asked to indicate the permitting requirements of their agencies, should a full scale geothermal District Heating System be proposed for construction. Based on the above information, a list of agencies and permits required was prepared.

The SCE Department with primary responsibility for obtaining each permit was then asked to estimate the required lead time to obtain each permit. The results, based on actual experience, are found in Table 10, Authorizations and Agreements, Mammoth Geothermal District Heating Project.

As indicated in Table 10, permit lead times vary from one to 49 months. The U.S. Forest Service Special Use Permit or Easement for the main supply and return pipelines from Casa Diablo to Mammoth Lakes Village is the longest lead time permit. Total processing time is estimated to be 49 months. Aside from the U.S. Forest Service Special Use Permit, the longest permit lead times are 15 months for the California Public Utilities Commission and Mono County Planning Department Permits. Therefore, if the estimated Forest Service permit lead time can be shortened, the entire permitting process can be shortened, accordingly. The 49 month lead time estimate is based on SCE's experience in obtaining Forest Service permits for projects of similar complexity and size. However, there does not appear to be any intrinsic reason why this permit should require more time than the others. In view of the national importance of the development of alternate energy resources, it should be possible to shorten the time required.

Because of the large approval time difference between the two longest lead time permits, it is recommended that DOE consult with the Forest Service in an effort to determine the reasons for past long lead times, and what actions may be taken to reduce the lead time for future projects. For the purposes of preparing schedules in the PROJECT SCHEDULE section of this report, the assumption has been made that the U.S. Forest Service permit, and all other necessary permits for the District Heating System can be obtained within 24 months.

TABLE 10

AUTHORIZATIONS AND AGREEMENTS
MAMMOTH GEOTHERMAL DISTRICT HEATING PROJECT

Agency/Authorizations and/or Agreements	Reason for Permit	Lead Times in Months Prior to Key Item: Application Preparation	Approval Time	Total	Key Item
FEDERAL AGENCIES					
1. U.S. Forest Services					
Special Use Permit or Easement	All facilities and activities on or crossing U.S. Forest Service land.	1	48	49*	Start of construction
2. Fish and Wildlife Service					
Administrative review of requirements and procedures having potential impact.	All facilities that require filing with U.S. Forest Service.	1 (Part of Federal, State, & Regional review)	1	2	Start of construction
3. National Park Service					
Land Use Permit or Administrative Review if not Lead Agency	All facilities and activities on or crossing National Park Service lands (pumping stations, transmission lines, service roads & soils & geological investigations).	1 (Part of U.S. Forest Service review)	1	2	Start of construction
STATE AGENCIES					
1. State Department of Fish and Game					
Administrative review of requirements and procedures having potential impact.	All facilities that require filing with U.S. Forest Service.	1 (Part of Federal, State, and Revional review)	1	2	Start of construction

*When submitting application the first time, an E.I.R. is not required; a determination will be made by Forest Service whether one is needed after review of the Scope of Work proposed. Lead time of 49 months would be shortened if E.I.R. is not necessary.

Agency/Authorizations and/or Agreements	Reason for Permit	Lead Times in Months Prior to Key Item			Key Item
		Application Preparation	Approval Time	Total	
STATE AGENCIES (Cont'd.)					
2. Public Utilities Commission					
Certificate if Public Convenience and Necessity	Facilities involving Geothermal Distribution	3	12	15	Start of construction for a facility geothermal heating
3. State Department of Transportation (Cal Trans)					
Encroachment Permit	Facilities that require construction, maintenance or repairs on or across State highways.	2	4	6	Start of construction
4. State Water Quality Control Board					
Use Permit	Any industrial, public or private project or development which would constitute a new or an increased source of controllable pollution to high quality water.	1	9	10	Start of construction
LOCAL AGENCIES					
1. Mono County Department of Building and Safety					
A. Grading Permit	1970 Uniform Building	1	3	4	Start of site prep.

Agency/Authorizations and/or Agreements	Reason for Permit	Lead Times in Months Prior to Key Item: Application Preparation	Approval Time	Total	Key Item
LOCAL AGENCIES (Cont'd)					
B. Miscellaneous Building Permits (foundations, buildings, tanks, etc.)	Code, Chapter 3, Section 301 (a) "Permits Required. No person, firm, or corporation shall erect, construct, enlarge, alter, repair, move, improve, remove, convert, or demolish any building or structure in the city, or cause the same to be done, without first obtaining a separate building permit for each such building or structure from the Building Office." All areas.	1	3	4	Start of construction for each permit
2. Mono County Department of Health - Sanitation District (17)					
Sanitation Approval	Any construction involving sanitation facilities	1	3	4	One month prior to start of construction
3. Mono County Department of Health					
A. Well Permit (core & exploratory drilling and cathodic protection wells)	Required for new construction, reconstruction, renovation and destruction of all water wells. Also required for all exploratory drilling in areas of potable water wells.	1/2	1/2	1	Start of drilling
B. Construction Trailer Permit	Required in some counties before the installation of construction trailer office.	1/2	1/2	1	Trailer installation

Agency/Authorizations and/or Agreements	Reason for Permit	Lead Times in Months Prior to Key Item: Application Preparation	Lead Times in Months Prior to Key Item: Approval Time	Total	Key Item
4. Mono County Planning Department					
Environmental Report	Any project having a potential impact upon the environment.	9	6	15	Start of construction
5. Mono County					
Franchise (New)	Facilities involving distribution within County area.	3	6	9	Start of construction

PROJECT SCHEDULE

An overall project schedule for a commercial District Heating System to serve Mammoth has been prepared in Figure 10. Assuming that environmental data collection can be begun by mid-1978, the residents and guests in Mammoth may be enjoying hydronic district heating by late-1982. The following paragraphs discuss each line item in the schedule, and present cost estimates for the engineering and design portions of the job.

A. PROGRAM PLAN

Before any major engineering or permitting activities can begin on the District Heating System project, a program plan must be completed. The purpose of the plan is to identify the participants and establish the ground rules upon which the entire project will be based. The program plan will include the following documents: A set of project procedures which define the owner's and engineer's project organizations, identify lines of communication, reporting requirements and project controls, and present a baseline project schedule and cost estimate; a quality assurance manual the purpose of which is to define and provide tracking for project QA procedures; and a design guide which will provide the basis for the detailed design of the entire District Heating System. The design guide will include a summary of all previous work on the project, the design and operating objectives of the system, and a set of economic evaluation factors for selection of equipment and design optimizations.

B. ENVIRONMENTAL DATA COLLECTION

The SAN/1316-4 report contains an environmental assessment of the District Heating System. The assessment considered environmental impacts in the areas of biology, archaeology, population, transportation and aesthetics. The assessment was based on field investigations in 1974 and 1977, and concluded that no potential adverse impacts could be identified which would preclude construction and operation of the system.

Many of the permitting agencies identified in the REGULATORY REQUIREMENTS section of this report will require significant environmental data in order to determine whether or not to issue permits for the system. During a six-month period starting in mid-1978, environmental baseline data for the Casa Diablo and Mammoth Lakes Village areas will be collected. This effort must be completed by the beginning of 1979 so that an environmental report can be started.

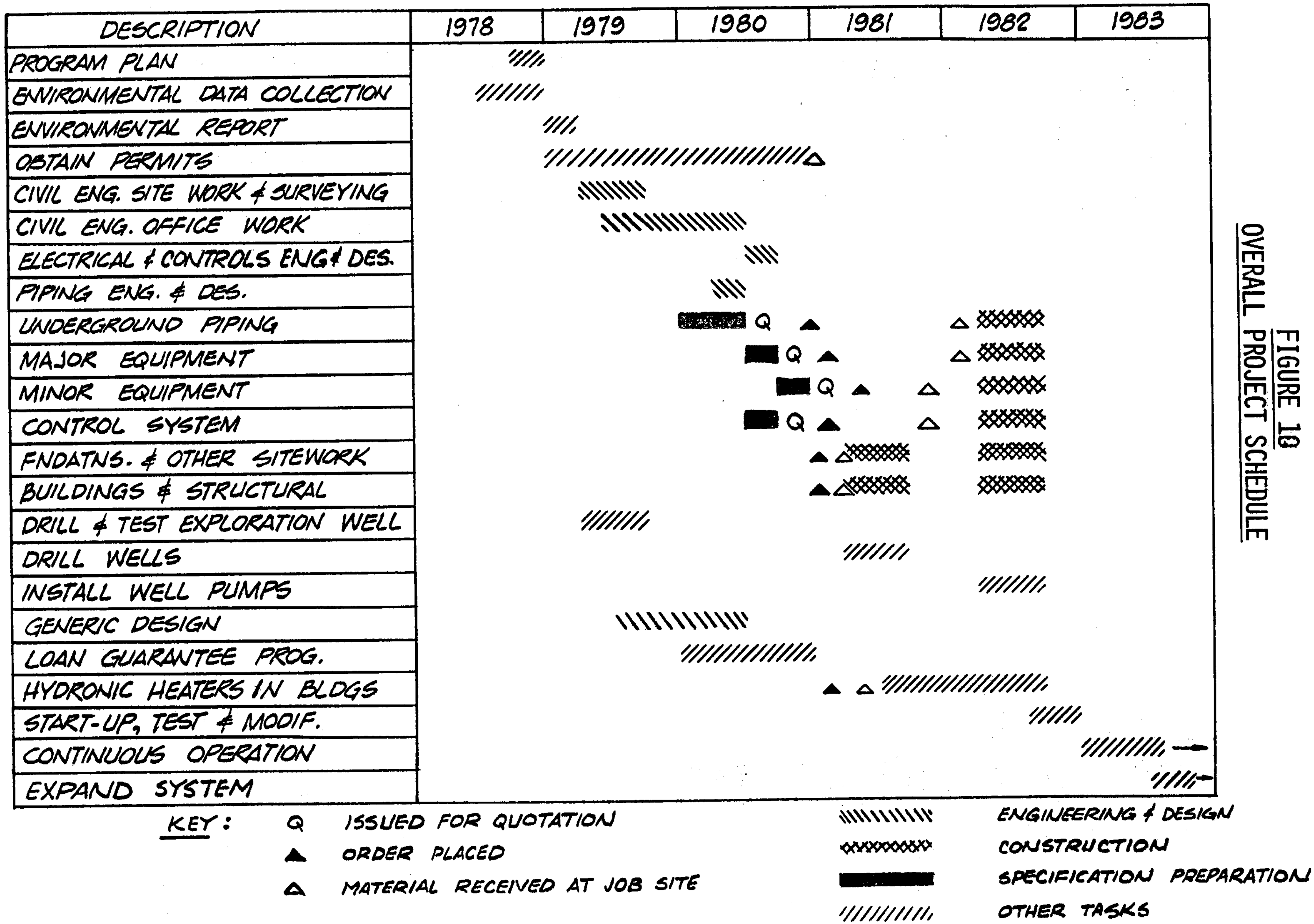


FIGURE 10
OVERALL PROJECT SCHEDULE

C. <u>ENVIRONMENTAL REPORT</u>

The County of Mono and U.S. Forest Service will probably be required to prepare Environmental Impact Reports or statements prior to reaching decisions on permit applications for the District Heating System. In anticipation of these requirements, an environmental report will be prepared for the system which will assist the above agencies in preparing their analyses.

D. <u>OBTAIN PERMITS</u>

The longest lead time permit, from the U.S. Forest Service, will be applied for in January, 1979. For the purposes of this schedule it is estimated that this permit can be obtained within 24 months, although previous experience has resulted in far longer lead times (see REGULATORY REQUIREMENTS section of this report). The lead times for all other permits are less than 24 months.

E. <u>CIVIL ENGINEERING</u>

Civil engineering tasks will be begun upon completion of the program plan and environmental report. Work grouped under this heading includes civil, structural and underground piping engineering and design. This work comprises the majority of the engineering effort on this job. The site work to be completed includes surveying and plotting centerlines and profiles of the entire 60 mile pipeline route. Office work involves preparation of engineering drawings and specifications for the following items, shown with cost estimates for each:

1. Foundations, Pipe Supports and Anchors for Brine Supply System -- $10,000

2. Site, Grading and Paving Plans for the Heating Plant -- $10,000

3. Office Building, Equipment Foundations, Pipe Supports and Anchors for the Heating Plant -- $15,000

4. Plans and Profiles for Main and Distribution District Heating Piping, including Highway and Secondary Road Crossings -- $245,000

5. Site, Grading and Equipment Foundations for the Hot Water Storage Tanks and Booster Pump Station -- $20,000

The estimated total cost of this work is $300,000.

F. <u>ELECTRICAL AND CONTROL SYSTEM ENGINEERING AND DESIGN</u>

The major items in the electrical engineering and design cost estimate are the following drawings, with the cost of preparation shown in parentheses; motor wiring ($8,000), lighting ($4,000), and instrument wiring ($4,000). Other expenditures include single line diagrams, specifications, material takeoffs and travel, bring the total estimated cost of this work to $25,000.

Work on the instrumentation and control system design will be done concurrently with electrical design. The cost of this work is estimated to be $10,000 for system design and specifications preparation, and $5,000 for procurement and follow-up work. The total cost of this work is thus estimated to be $15,000.

G. PIPING ENGINEERING AND DESIGN

Design and engineering of all aboveground piping will be completed under this task, the underground piping design is covered in the CIVIL ENGINEERING task described above. The following items with their estimated costs of completion are included in this task:

System Piping and Instrumentation Diagrams	$ 2,000
Utility Flow Diagrams	1,000
Area Plot Plans	3,000
Aboveground Piping Assembly Drawings	11,000
Spooling Details	3,000
Material Takeoffs	2,000
Specifications	1,000
Piping Stress Analysis	2,000
Piping Supervision and Travel	5,000

The estimated total cost for this work is thus $30,000.

H. UNDERGROUND PIPING

It is anticipated that all underground piping in the District Heating System will be factory insulated with polyurethane foam. This type of piping has a lead time from procurement to delivery of from 12 months to 18 months, making it the longest lead time item of material or equipment for the project. In order to minimize the effects of this long lead time on the project schedule, the piping should be specified and the vendor selected prior to obtaining all permits for the project. When the last permit is received, the vendor selected will be authorized to begin fabrication of the piping. The piping will begin arriving in Mammoth early in 1982, and installation will begin as soon as the weather allows (probably late spring).

I. MAJOR EQUIPMENT

The major plant equipment, including hot water circulation pumps and geothermal/fresh water heat exchangers, will be ordered shortly after the factory insulated piping. The lead time for delivery of this equipment is less than one year. Installation will begin in spring, 1982.

J. OTHER EQUIPMENT AND CONTROLS

Other plant equipment and plant instrumentation and controls will be ordered for delivery and constructed concurrently with the preinsulated piping and major equipment.

K. FOUNDATIONS AND OTHER SITEWORK

Site grading and placement of foundations for equipment and structures may be completed prior to delivery of any equipment. The site work for the heating plant and each hot water storage tank location will be completed in 1981, along with the foundations for major equipment at each location. Excavation of trenches for underground hot water piping, and placing of the piping anchors, supports and manholes will be completed in 1982 when the piping system is installed.

L. BUILDINGS AND STRUCTURAL

The heating plant office/shop and control room building will be erected in 1981. The building will then be used as a project office until initial construction and start-up are completed in 1982. The structural steel for major system equipment will also be installed in 1981.

M. EXPLORATORY WELL

Magma Energy, Inc. has indicated its intention to drill a 9,000 foot exploratory well at Casa Diablo as soon as possible. However, Magma's permit to do so has been challenged on the grounds that the drilling and subsequent activity may irreversibly damage valuable archaeological sites. For the purposes of this schedule, it has been assumed that the well will be drilled, completed and tested during 1979.

N. WELLS AND WELL PUMPS

The necessary new production and injection wells will be completed and tested, and reworking of existing wells will be accomplished during the spring and summer of 1981. Well pumps will be purchased by the resource producer for delivery in early 1982 and installed during final District Heating System construction by mid-1982.

O. GENERIC DESIGN

As mentioned in the SAN/1316-4 report, only two hydronic heating systems were identified in the Village, and 85 percent of the heating systems rely on resistance electric heaters. Because of the lack of familiarity among Village residents with hydronic heating systems, typical hydronic heating system designs will be made to allow property owners to select a design which is appropriate for their building. These generic designs will also be made available to architects and contractors to assist them in planning for new construction.

P. LOAN GUARANTEE PROGRAM

An attempt will be made to establish a program by which building owners may obtain low cost financing to retrofit their buildings with hydronic heating systems, or install hydronic systems in new construction. This program will help assure that a maximum number of buildings are using geothermal district heating at the earliest possible date. Both the State of California and Federal Government will be asked to assist by providing tax credits and/or loan guarantees to potential District Heating System customers.

Q. HYDRONIC HEATERS

Village residents and building owners will be encouraged to construct hydronic space, water, jacuzzi, swimming pool heating, and snow melting systems. Owners can install heaters anytime prior to the completion of initial District Heating System construction in fall, 1982, and use the system from its beginning. Users who install hydronic heaters after 1982 may tie into the District Heating System at that time.

R. START-UP, TEST AND MODIFICATIONS

Start-up and checkout of individual pieces of equipment will begin prior to completion of system construction. Once construction has been completed, each subsystem can be individually started up. Finally the entire District Heating System can be operated as a whole. After system testing, modifications will be made so that the system may begin commercial operation for the 1982-83 winter season.

S. CONTINUOUS OPERATION

The District Heating System will be commissioned for continuous operation in January, 1983.

T. EXPAND SYSTEM

Hot water piping mains, and storage tanks will be initally constructed to serve a 60 MWt heating load. However, components such as heat exchangers, circulating pumps, wells, hot water distribution branch lines and service connections to buildings will be constructed to serve the inital load and increased in size and/or number as the system load increases to its projected maximum of 60 MWt. The initial system peak load is anticipated to be about 5-10 MWt, growing to 60 MWt over a period of about eight years. The SAN/1316-4 report contains details of the projected system growth.

The cost of project management and engineering, procurement and project administration for the District Heating System is estimated to be about $480,000. The breakdown of this estimate is:

Project Engineers (also responsible for procurement):

1 full time, 4.5 years @ $25/hr	$234,000
1 full time, last 2 years only @ $25/hr	104,000

Project Manager:

Half time for 2 years, plus full time for final year @ $30/hr	125,000

Administrative Costs:

400 hrs @ $42.50/hr	17,000

The total costs attributable to the engineering and design of this project are thus:

Civil Engineering	$300,000
Electrical Engineering	25,000
Piping Design	30,000
Control System Design	15,000
Project Engineering and Management	480,000

Therefore, the total design, engineering and procurement costs for the project are estimated to be $850,000.

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