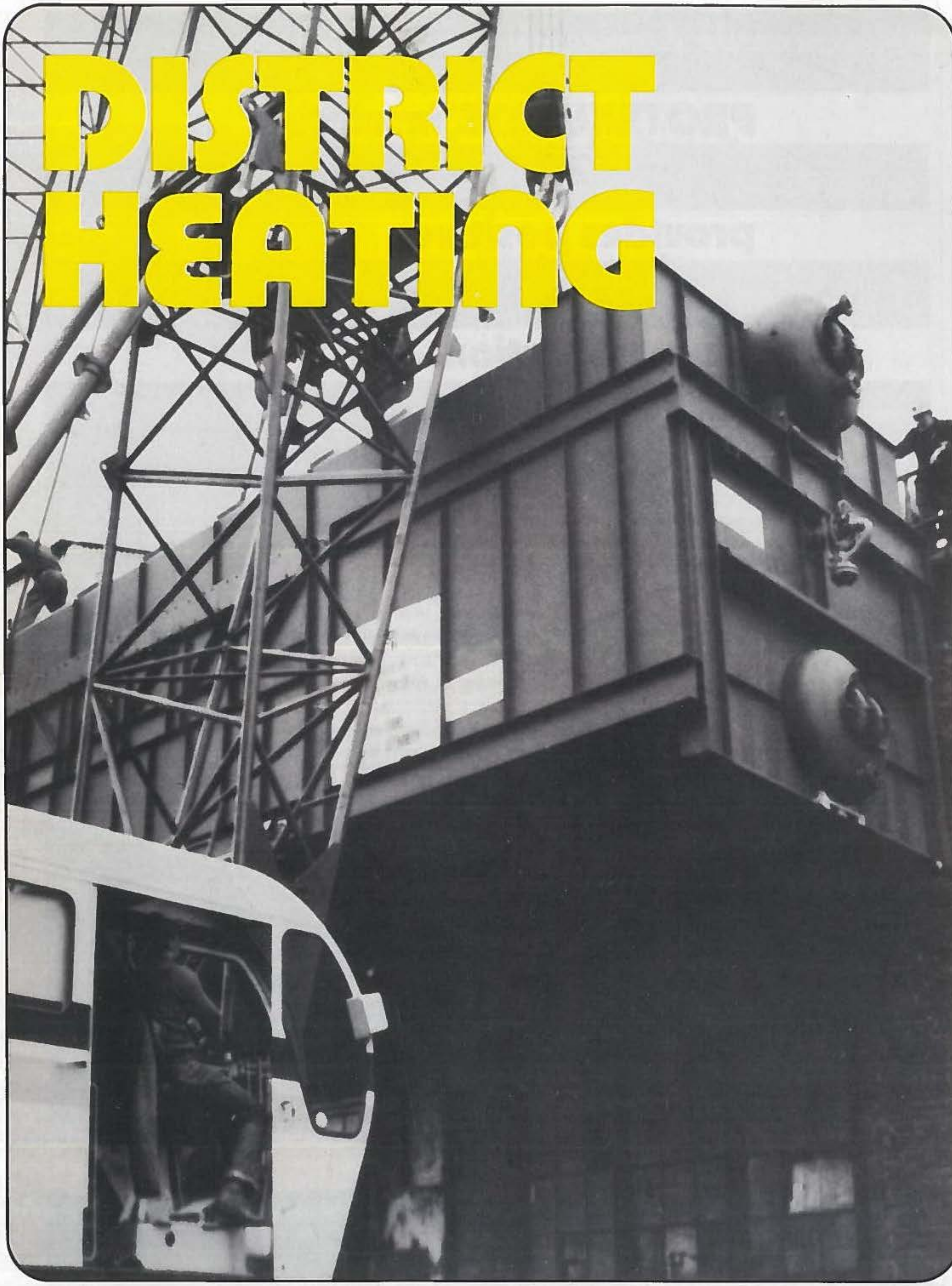
DISTRICT HEATING



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Geothermal District Heating Projects

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Introduction

The geothermal energy stored within the interior of the earth amounts to a significant quantity which, if fully exploited, could supply the energy needs of man for a millennia. Low temperature hydrothermal resources underlie vast areas of the United States as illustrated on Figure 1, particularly in the western half of the country. The U.S. Geological Survey has identified 1,346 hydrothermal convection systems of which 1,294 have temperatures less than 300°F and are considered suitable for direct heat applications (Reed, 1983). Resource temperatures greater than 300°F are considered economic for electrical generation. Quantitative estimates of identified low and intermediate temperature (less than 300°F) geothermal systems contain 68.3 million billion Btu's of beneficial heat for 30 years.

In the past, the use of geothermal water in the United States was primarily for hot water baths and pools (balneology). After 1920, however, the abundance of inexpensive natural gas for heating baths and pools caused a rapid decline in the use of natural hot water. Some use of geothermal water for space heating dates from before 1890 in such areas as Boise and Ketchum, Idaho and Klamath Falls, Oregon. In the 1930's, the Boise system provided heat to over 400 homes and at Ketchum about 60 homes and businesses were heated with geothermal water. At Klamath Falls nearly 600 geothermal wells are used to heat individual homes and commercial buildings. Interest in this application has been rather slight until the 1970's.

District heating systems have received increasing attention in the past few years because they make more efficient use of energy resources. An inventory identifies a total of 1,277 hydrothermal sites within five miles of 373 cities in eight western states, with a combined population of 6,720,347 persons. The combined heat load for all cities (exclusive of industrial loads) is estimated at 132,558 Btu's per year (Allen, 1980). Eight cities have implemented geothermal district heating and 38 other cities are in initial stages of feasibility analysis and resource assessment.

This paper describes the seven operating geothermal district heating systems and Table 1 shows relevant data for each system.

Boise District Heating System

Boise, Idaho has utilized its geothermal resources for nearly a century and established the Boise Warm Springs Water District (BWSWD), which at one time delivered geothermal water for space heating over 400 homes. The city is presently upgrading and expanding its existing residential goethermal system (BWSWD) and has developed a new district heating system (Boise Geothermal) that is providing heat to the downtown central business district. The new system, which began operating in March 1983, already includes 15 retrofitted buildings and is in the process of connecting five more.

The Boise Geothermal System consists of four production wells (Table 1), 13,000 feet of insulated distribution pipeline and about 17,000 feet of uninsulated collection pipeline. The distribution pipelines varies in diameter from 14 inches at the wellheads down to eight inches at the end of the pipeline in downtown Boise (Figure 2). The pipeline has a nominal design capacity of 4,000 gpm, carrying geothermal fluid at 170°F which is discharged into the Boise River at a temperature of about 120°F. System heating capacity depends upon three system parameters: 1) a peak flow rate of 4,000 gpm; 2) an overall system load factor of 25% per year (5,833 average degree days per year and a minimum design temperature of 0°F); and 3) a temperature drop of 50°F in a building's heating system. From these parameters, the heating capacity of the Boise Geothermal System was calculated at 220 billion Btu's per year. Approximately 16.7 billion Btu's were delivered from October 1983 to May 1984 displacing 22.2 billion Btu's of natural gas.

Boise Geothermal purchases water from a drilling partnership who agreed to drill the production wells when it became apparent that funding to Boise Geothermal would not be large enough to construct the desired geothermal system. Boise's agreement with the partnership contained the following main provisions (Merz, 1982):

1. Boise granted the drilling partnership a 30 year lease to the mineral rights to extract geothermal water from property believed to encompass the geothermal resource.
2. The drilling partnership agreed to drill sufficient wells to produce 2,000 gpm.
3. Boise agreed to obtain contracts for the use of 2,000 gpm of geothermal water and up to 4,000 gpm.
4. Boise agreed to purchase the water from the drilling partnership at a 46% discount from the price of natural gas when the water was purchased.

The terms of this agreement were negotiated and agreed to with the specific intent of compensating the drilling partnership for incurring the risks inherent in drilling wells to search for an unproven resource.

Table 1
Geothermal District Heating Project Summaries

District Heating System	Well Depth (feet)	Fluid Temperature (°F)	Flow Rate (gpm)	Peak Thermal Power (MW_t)	Start Up of Oper-ations	Captial Costs (1982$) (thousands)	Annual O & M Costs (1982 $) (thousands)	Annual Energy Delivered (10^9 Btu)	Payback Period (years)
Boise, ID	2,010	167-174	600 to 900		1983	7,128	51.7	80.6	10
	800								
	1,893		design capacity						
	1,102		4,000	29.3					
Capitol Mall	3,030	162	750	4.6	1982	1,850		34.5	7
	2,150								
Elko, NV	850	178	400	2.9	1982	1,126	21.6	21.5	9
		30Δt	design cap. 750						
Klamath Falls, OR	350	224	750	6.2	1984	2,801	9.0	51.0	14
	900	213							
Pagosa Springs, CO	275	148	900	3.8	1984	1,364	72.7	28.6	16
	300	131							
Philip, SD	4,266	157	340	1.6	1980	1,209	4.0	9.5	14
San Bernardino, CA	975	138	3,000	15.4	1983	2,750	125.0	127.6	7-10
Susanville, CA	935	170	718	3.2	1982	2,400	57.0	20.7	17
	500+	150	300						
Litchfield Prison	1,500	180	1,000	4.4	1983	2,172	30.0	60.0	9
	1,400	160	1,500 capability						

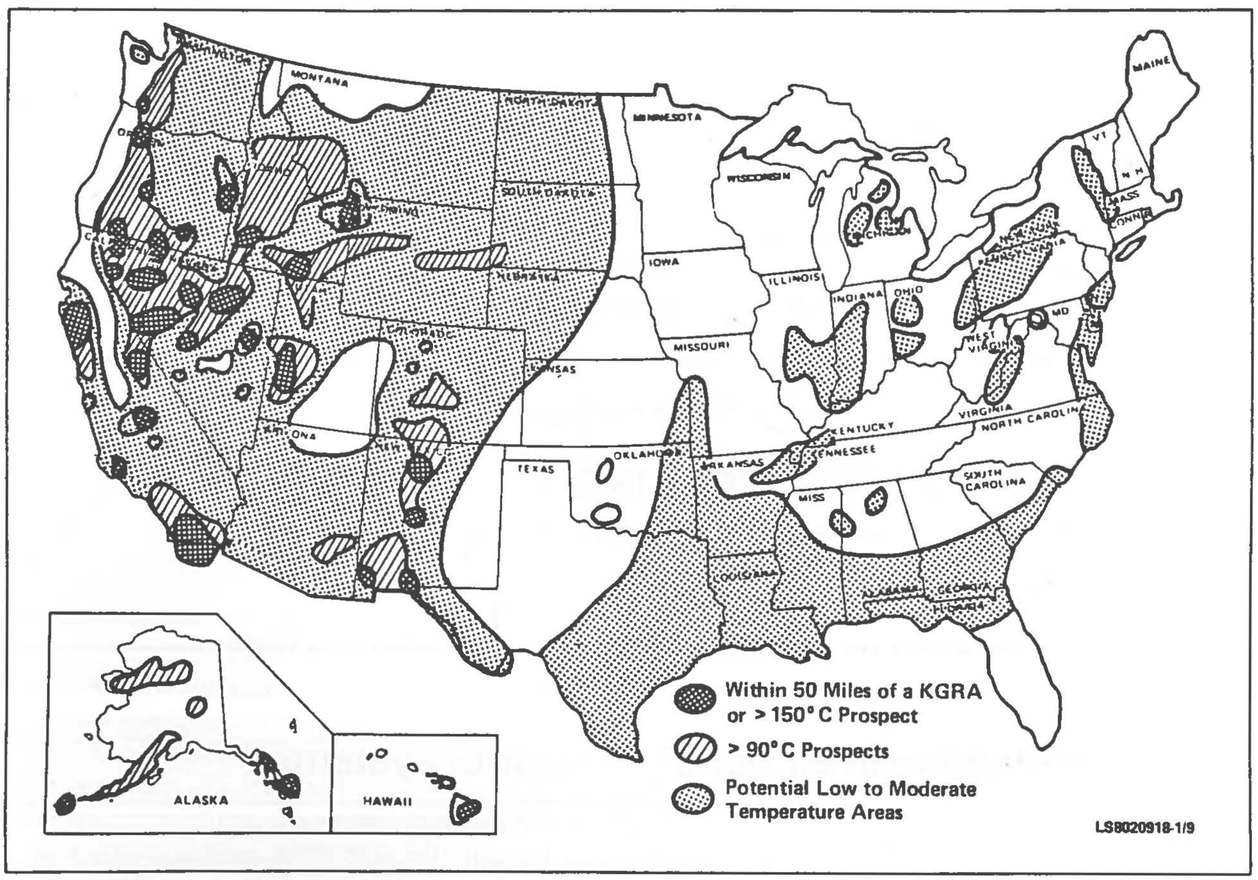

Figure 1
Known and Potential Hydrothermal Resources
(Interagency Geothermal Coordinating Council, 1980)

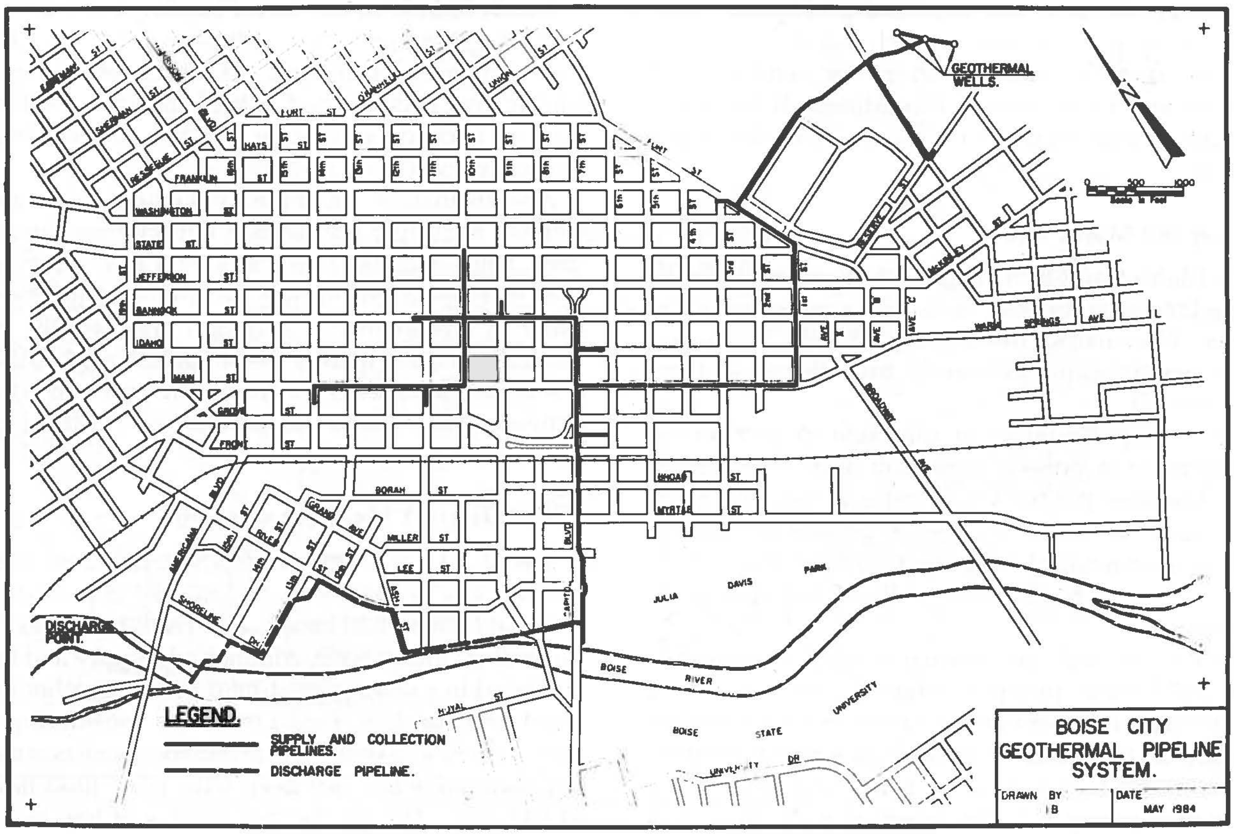

Figure 2
City of Boise, Idaho
District Heating (Gordon, 1983)

The pricing scheme Boise is currently using guarantees a 30% savings over the price of natural gas if the customer removes enough heat per gallon to reduce the temperature by 50°F. The geothermal pricing formula is:

$$(\text{Natural Gas Price}/.75) \times .70$$

which is adjusted for conventional system efficiency.

Based on a 1982 analysis (Merz, 1982), the total per therm estimated cost of geothermal energy is summarized in Table 2 for peak flow rates of 2,000 and 4,000 gpm. Cost items 2, 3 and 4 are considered fixed costs in that the total dollar amount of these costs will not vary with amount of energy delivered by the system. The unit costs of these items will depend upon the total therms delivered. The actual price to customers according to the geothermal pricing forumla for the period December 1983 to May 1984 is also shown.

This pricing scheme encourages conservation of water usage by customers which is good in terms of the resource. However, revenues to Boise Geothermal are also reduced as a result. Boise Geothermal sold 40 million gallons of water during the period October 1983 to May 1984. Retrofits are the responsiblity of the

Table 2
Cost—Price Relationship

Boise Geothermal Costs (1982 estimate)	**Per Therm**	
	2000 gpm Peak	**4000 gpm Peak**
1. To Drilling Partnership	$.302	$.302
2. Depreciation	.036	.018
3. Billing & Administration	.014	.007
4. Maintenance	.032	.016
Totals	$.384	$.343
Price to Customers (Dec. 83 to May 84)	**Per 100 Gal**	**Per Therm**
0 to 49,000 gal	$.2000	$.5282
49,000 to 441,000 gal	.2140	.5138
Greater than 441,000 gal	.2062	.4951

customer and Boise has provided preliminary estimates of prospective user's need and retrofit costs. The city has provided workshops for vendors, and the Economic Development Department of the city is considering offering users low interest loans to finance retrofits.

The Capitol Mall Project

The Idaho Capitol Mall, consisting of seven buildings, is located at the edge of the Boise central business district. This district heating system was developed and is operated independently from Boise Geothermal's system.

The principal interest of the state in geothermal development in Boise is reduction of its own energy costs. The state planned to become a customer of the city system, however, the cost of private investment (drilling partnership) in Boise Geothermal's system made it cheaper for the state to build and operate its own system.

The Capitol Mall geothermal heating system provides 162°F water pumped from the production well and circulated to mechanical rooms of each building through the pipe located in the Mall's tunnel system. The geothermal water is cooled to approximately 120°F and is then pumped to the injection well where it is then returned to the underground reservoir as shown in Figure 3.

Nearly 750,000 square feet of building space is heated, including the capitol and adjacent state office buildings. The existing natural gas steam heating system for the Mall was retained as backup to the geothermal system and for supplying additional heat requirements on extremely cold days.

Approximately 750 gpm of geothermal water is needed to supply the heating energy requirement of the Capitol Mall on a typical winter day. Ninety percent or more of the annual heating load will be supplied by the geothermal system. This results in an annual savings of natural gas of approximately $150,000 a year based on the 1981 costs. The graph in Figure 4 shows a projection of the savings to the state of Idaho through 1990.

Elko District Heating system

The Elko Heat Company geothermal project in Elko, Nevada is a private venture designed to provide geothermal heat to two banks, five retail buildings, auto dealership, motor hotel, commerical laundry and finally cascaded to a sewage treatment plant. Another motor hotel and the U.S. Post Office are considering connecting to the system. The production well is artesian, approximately 850 feet deep with 178°F fluid flowing at 500 gpm. The geothermal fluid is of low chemical content, therefore, is circulated directly through most of the buidlings' heating systems.

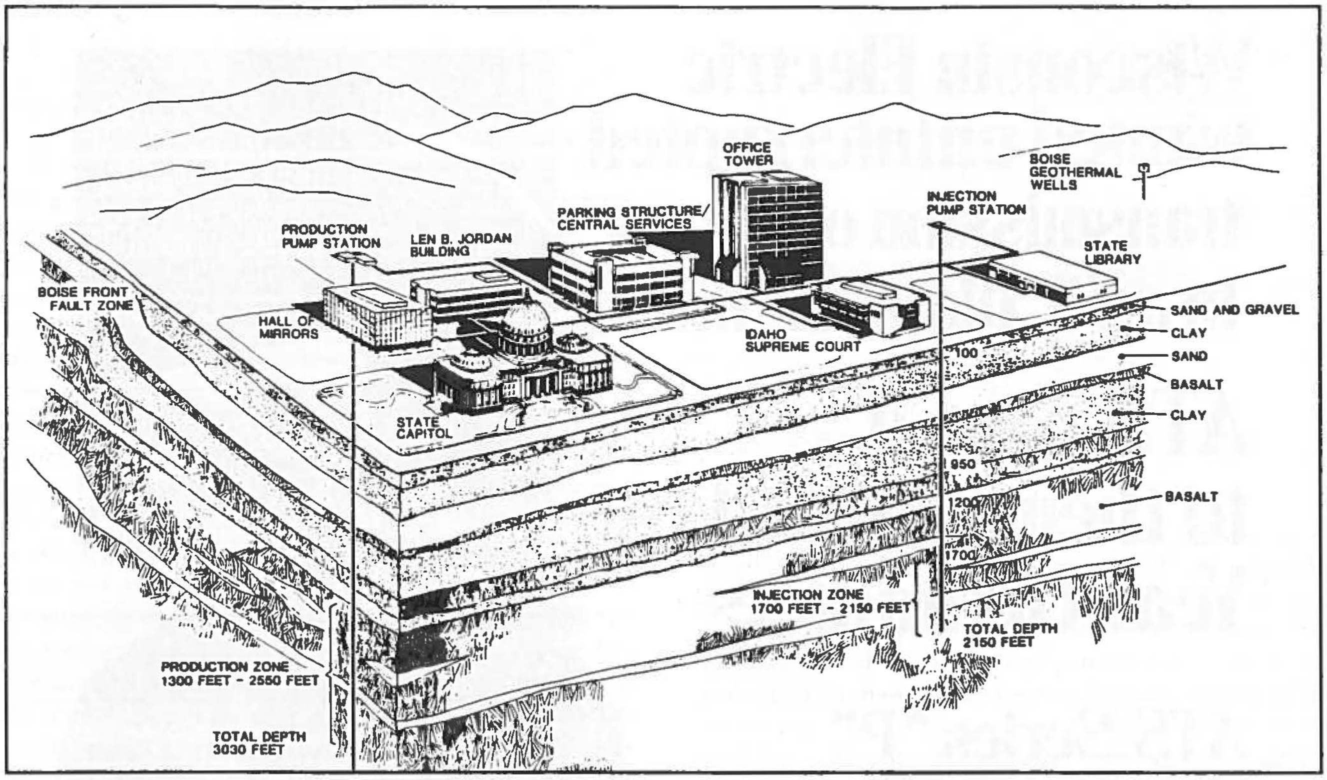

Figure 3
The Capitol Mall Project (Street, 1983)

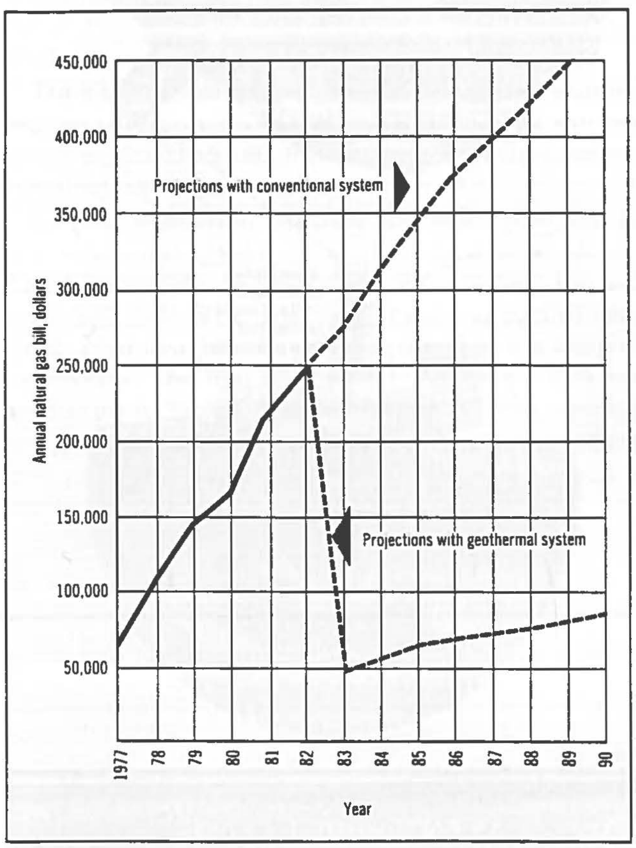

Figure 4
Natural Gas Savings for
the Capitol Mall (Street, 1983)

The geothermal system is currently displacing about 30.7 billion Btu's of natural gas per year, which is 100% of its users' natural gas needs. At capacity, Elko's well is capable of displacing about 40 billion Btu/s per year.

Elko is presently charging its customers about 50% of the price of natural gas. This is based on a 30 to 40°F temperature drop through the heating systems and a 70% combustion efficiency of natural gas. Elko charges at a gallonage rate of $1.00 to $1.25 per 1,000 gallons of geothermal fluid.

As a private venture, the owners of the Elko system are looking for a 15 to 20% rate of return and can expect a payback of all costs in approximately nine years.

Installation and maintenance of flow meters are the responsibility of the user, and meters are located inside users' buildings. The customer is responsbile for building retrofit, but Elko Heat Company does offer a preliminary estimate of users' needs. The marketing obstacles in connecting new customers has been the user not understanding geothermal energy, building owners uncertainty about its reliability and the cost of retrofits.

Klamath Falls District Heating System

At Klamath Falls, Oregon the first phase (6.2 MW) initially serving 14 city, county, state and federal office buildings and 120 homes has been completed of a planned 54 city block (41.8 MW) central business district heating system (Figure 5). The project includes two production wells, injection well, primary and secondary pipelines, central pumping and heat exchanger, controls and retrofitting equipment for the government buildings. Initial funding is over $2.8 million, consisting of 65% federal funds, and the remainder from city, county and state funds. The primary pipeline delivers 750 gpm of geothermal water at design conditions for Phase I to a central heat exchanger building. The primary pipeline runs a distance of 4,100 feet and is housed in a 3′ × 4′ concrete conduit that contains space for future piping. Steel pipe insulated with 2 inches of urethane was chosen due to the high temperature (above boiling) of the primary geothermal water. The central heat exchanger building houses controls for the system including telemetry to production wells and also centrifugal split case pumps for the secondary double pipe system. The wells work on both temperature and flow requirements basis, i.e. increased demand on the secondary side would, through telemetry, automatically increase the pumping rate from the production wells. Table 3 gives the design conditions for the two plate type heat exchangers shown in Figure 6.

The secondary pipeline is constructed of fiberglass reinforced plastic pipe (FRP), again insulated with 2 inches of urethane. This double piping system is direct buried and is sized from a maximum diameter of 10 inches down to three inches to service all the buildings along its route (3,538 feet), should at some time in the future those buildings be added to the system (Lienau, 1981).

The Klamath Falls district heating system's revenues will be based on a fixed rate per million Btu's in the range of $2.00 to $3.00, but not related to any conventional energy price.

Retrofit assistance, which is primarily applicable to the residential system, is available in several forms. The Community Development Block Grant has set aside $200,000 to be used for a revolving retrofit loan fund. Also, two bills have been passed in the Oregon legislature. The first bill offers tax payers a 25% tax credit (up to $1,000) for retrofit costs if they connect to a geothermal heating system, and the second offers 25% (up to $1,000) for the expense of the connection itself.

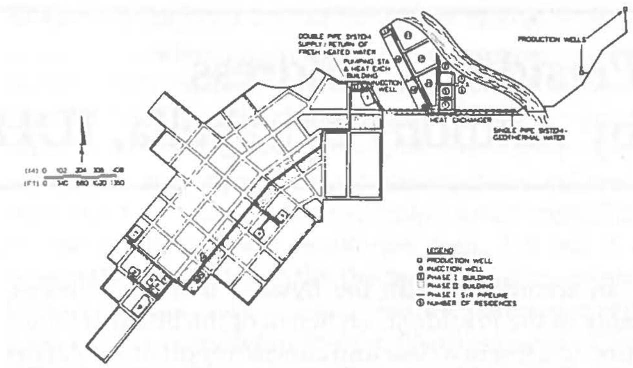

Figure 5
Klamath Falls, Oregon District Heating

The city of Klamath Falls has encountered difficulties regarding institutional factors. Citizens objected to the pumping of additional fluids from the geothermal reservoir, delaying the project from Spring 1982 to Spring 1984. Hundreds of private wells use downhole heat exchangers to heat individual homes in the same area, and concern was about drawdown of the reservoir. This issue has not been resolved and is pending in the Courts.

The remainder of this article will be printed in the next issue of District Heating.

Figure 6
Heat Exchangers and Pumping Station

TABLE 3
Design Operating Conditions

Heat Exchanger	Geothermal Fluid Temp. (°F)	Geothermal Fluid Flow (gpm)	Circulating Fluid Temp. (°F)	Circulating Fluid Flow (gpm)
Inlet	219	750	160	750
Outlet	176	750	200	750