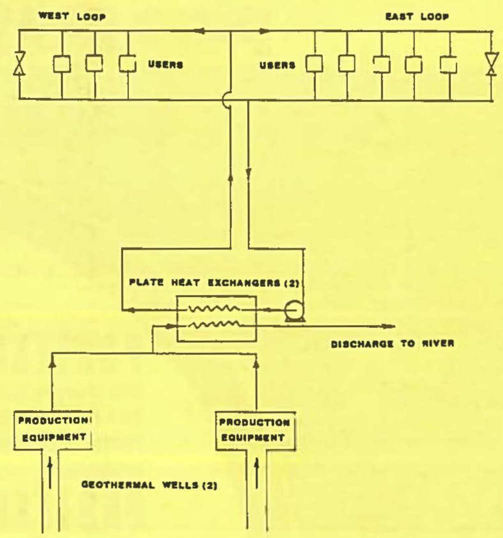
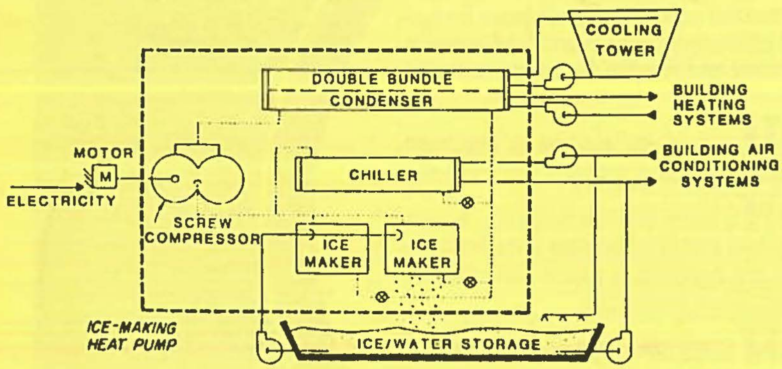
DISTRICT HEATING

HEAT PUMPS





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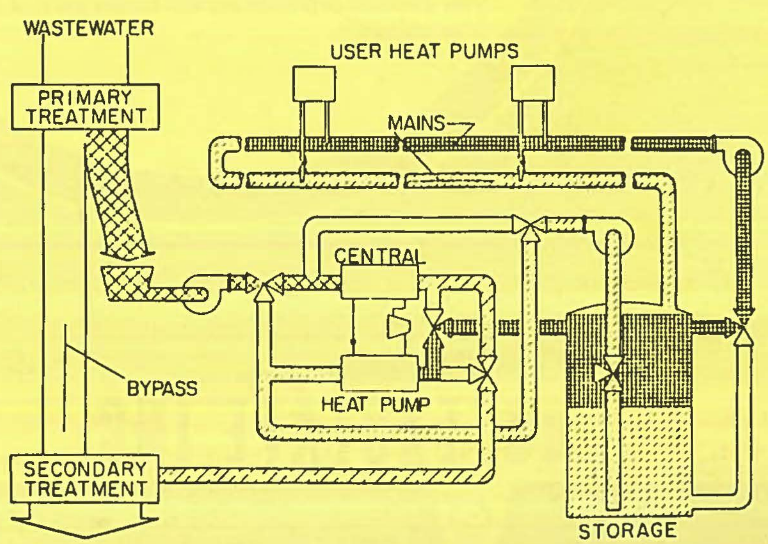

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Geothermal District Heating Projects

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This is the continuation of the article started in the 3rd quarter 1984 District Heating Magazine.

Pagosa Springs District Heating System

The geothermal resource supporting the Pagosa Springs, Colorado system lies directly under the town. Two wells drilled to a depth of 300 feet provide a combined artesian flow of 2,000 gpm at 140°F. This hot water can supply the space heating needs of nine public buildings, 54 businesses, and 63 residences. The initial system utilizes 900 gpm of geothermal fluid but will be capable of expansion to 1,800 gpm as that proves desirable (Garing, 1983).

Heat energy from geothermal waters is transferred to circulating waters in an independent distribution system. This closed distribution system consists of two separate loops, one for each side of town. This design feature provides the flexibility to shut off either loop in the event of required pipeline maintenance, and it facilitates additional expansion in future years. Two plate heat exchangers are used to heat city water which is circulated in each of the two loops by means of one to four pumps, depending on user demand. The cooled geothermal fluid leaving the plate heat exchangers is then discharged into the San Juan River. Two parallel pipelines form each loop, an insulated asbestos cement pipe carries the heated circulating water to consumers, and an uninsulated pipe returns the cooled circulating water back to the heat exchangers. The installed system is shown schematically in Figure 7.

The control scheme controls the four circulating pumps, flow from the geothermal wells, and temperature of the circulating water leaving the heat exchangers. The intent of the control system is to minimize both the operating costs and manpower requirements for operation over a broad range of conditions. At flows less than 1,000 gpm, only one geothermal well and one heat exchanger will be in service. Flow from the geothermal wells is controlled by the discharge temperature of the circulating fluid. This temperature controller operates a throttling valve on the geothermal supply line to maintain a constant discharge temperature from heat exchanges.

Two types of Btu meters for measuring consumer energy use have been installed at Pagosa Springs. The first type monitors on the basis of constant flow combined with hot side and cold side temperature measurements. The energy extracted in the user installation is cumulatively summed and recorded, and the user is billed on that basis. A second meter type mea-

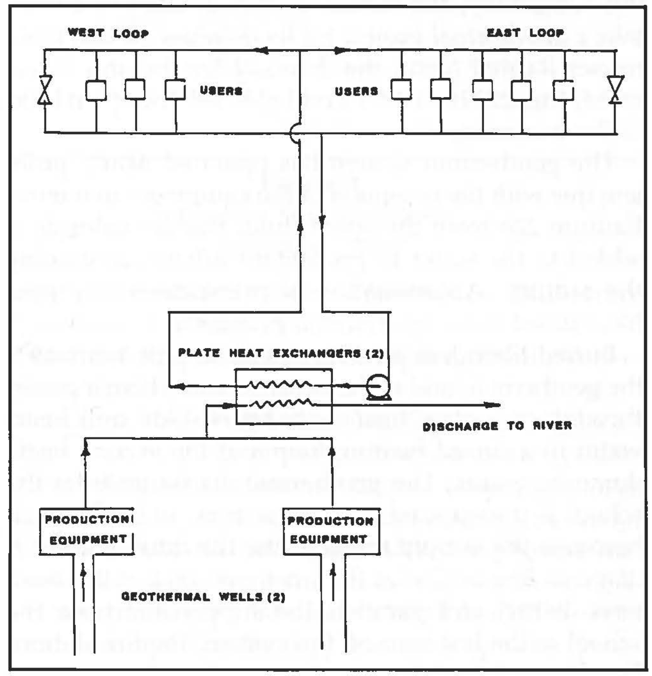

Figure 7
Pagosa Springs, Colorado
District Heating

sures both variable flow and the varying temperature difference across the consumer installation where large and fluctuating ranges of energy use are expected. The city is paying for installation and maintenance of the Btu meters necessary for billing. First year data collected indicate that cost savings to individual users is 43% of the price of natural gas. The comparative heating cost in $ per million Btu at Pagosa Springs are $3.35 for geothermal, $7.85 for natural gas, $8.94 for propane and $17.40 for electric.

Customers are responsible for retrofitting their buildings, including secondary piping from the property line to the structure. The city offers assistance in retrofit engineering.

As a municipal utility, Pagosa Springs is not subject to regulation by the state. There has been strong citizen opposition to the district heating system's use of the resource. Many members of the community have their own geothermal wells and are afraid that the city may drawdown the level of the underground reservoir.

Philip District Heating System

The Philip, South Dakota geothermal project comprises a small scale district heating system. The town overlies the Madison Formation which is a large aquifer found in the states of South Dakota, North Dakota, Montana and Wyoming. At Philip, 157°F fluid flowing at 340 gpm from a 4,266 foot artesian well in the Madison aquifer is delivered to five school buildings and is then cascaded to nine business district buildings (Childs, 1983).

The Haakon School District's geothermal project is a unique combination of institutional and district heating. Originally, the school district decided to undertake a geothermal project for its own use. When businesses located along the disposal line became interested, the school district decided to sell the spent fluid to the businesses.

The geothermal system has operated nearly problem free with the exception of the equipment to remove Radium 226 from the spent fluid. Barium chloride is added to the water to precipitate sulfates containing the radium. Accumulation of precipitates in piping has caused some operational problems.

Buried fiberglass reinforced plastic pipe transports the geothermal fluid to the boiler rooms. There it passes through two plate heat exchangers. One unit heats water in a closed heating loop and the second heats domestic water. The geothermal discharge from the school is transported in a single pipe at 130°F which becomes the supply through the downtown area. A disposal line begins at the upstream end of the business district and parallels the supply line from the school to the last user on the system, the fire station. From there, a single line continues to the radium removal plant and disposal in the Bad River (Figure 8). Geothermal supplies 75 to 90% of the nine business buildings' energy requirements.

It was observed that the school removes that 16°F and the business district about 11°F from the peak flow rate of 340 gpm. This was under extremely cold conditions (−35°F) which occurred once in the last three years. The system was designed for a usable temperature drop of 32°F. Even at this extreme condition only 83% of its design capacity was used.

Revenues for the Philip system present an interesting twist, since the venture originated as a user owned arrangement. Consequently, the school district is only interested in its energy savings and not in recovering part of its investment from businesses. The school district has decided to charge a flat fee to the business district of $2,500 per year for the first five years, doubling by 1990. The business district currently saves an estimated $47,500 per year. The fee is designed to defray some of the costs of the barium chloride treatment plant. If the school district received about 50% of the savings obtained by the business district, it would reduce the simple payback to the school district from 14 to 10 years.

San Bernardino District Heating System

The city of San Bernardino, California uses a low temperature (138°F) resource to provide heat for a two million gallon anerobic sludge digester. The expanded

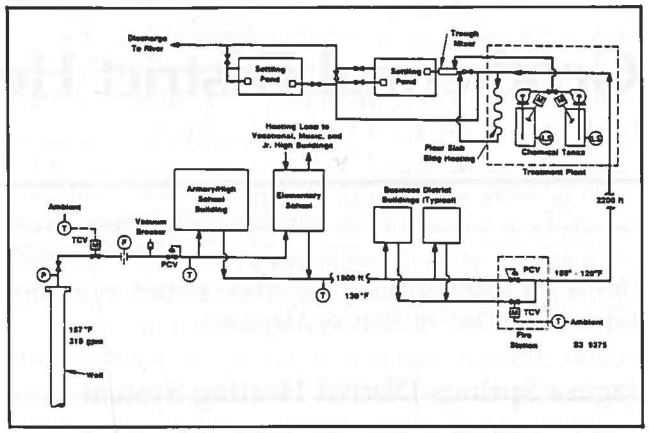

Figure 8
Philip, South Dakota
District Heating (Childs, 1983)

use includes heating two more digesters and a district system for 87 potential buildings. The city's 975 foot geothermal well has an artesian flow of 3,000 gpm at 138°F. Currently, 600 gpm is used to provide 1.5 million Btu's per hour to the sludge digester and space heating for seven buildings. The new system, which began operating in April 1983, has contracts to connect 60% of the 87 potential users. One of them, a 12 story Ramada Hotel is scheduled to be on line by October 1984.

The anerobic bacteria digestion process requires a temperature of 90 to 98°F to function efficiently. The 138°F geothermal fluid is piped 4,400 feet to the digester where it heats the sludge from 75°F to optimum 98°F, using a spiral plate heat exchanger. Five buildings at the plant are also heated geothermally.

The geothermal resource appears to be fault controlled, with hotter water (up to 185°F) near the San Andreas fault. Within the city, the Loma Linda and San Jacinto faults probably are the controlling mechanisms, with the warmest water on the eastern side of the Loma Linda fault. Two additional production wells are planned for the near future. The total dissolved solids (TDS) of the existing resource are less than 300 ppm. Because the dissolved minerals are in such low concentrations, the Environmental Assessment and NPDES Discharge Permits have been approved to discharge cooled geothermal water into natural drainage channels.

In concept, the district will encompass users in south and central San Bernardino, including Norton Air Force Base. Identified potential users include 47 public sector buildings and 40 in the private sector.

The city of San Bernardino Board of Water Commissioners sells the geothermal energy at 50% of the price of natural gas until retrofit costs are payed back and after that it will never exceed 75% of the 1981 natural gas price. The city is expected to have gross revenues of approximately $670,000 during 1985, the first year of the loan repayment. The operating costs of the district for 1985 will be $125,000. The balance of revenues will be adequate to repay the loan principal and interest in ten equal annual payments.

The completed project, possibly by 1986, will have two or more wells (a contract has been awarded for the second well), and five miles of city owned insulated pipeline. User retrofit will be repaid by savings on energy costs, which will include the cost of heat exchangers and user installed interconnects.

Susanville District Heating System

The geothermal district heating system in Susanville,, California is designed to provide space heating for three separate district heating loops. The first geothermal loop, in operation for the 1982-83 heating season, circulates 170°F fluid to seventeen public buildings. A second geothermal district heating loop provides heat to 126 homes (Figure 9). A greenhouse complex, shortly scheduled for completion, may utilize cascaded energy from the heating district. Finally, the Litchfield prison facility is to be provided with geothermal fluid from two new production wells. Plans underway also allow a planned industrial park access to the 150°F fluid leaving the prison.

Susanville's present level of operation is about half its design capacity. This is due to the fact that California considers geothermal fluid a hazardous waste. Consequently, Susanville has had difficulty finding a suitable disposal method and obtaining permits. Use during the 1983-84 heating season was limited to seven high school buildings (700,000 square feet) because the injection well would only accept 150 gpm. Starting with the 1984-85 heating season, 17 public buildings and 23 homes will be connected to the system. A surface discharge permit has been obtained from the Department of Water Resources and water will be discharged into an irrigation ditch in addition to the injection well. In addition, a 5,000 foot pipeline has been built which will connect 23 of the 126 homes on the residential district heating loop. Susanville is negotiating with the greenhouse owner to cascade 65,000 square feet of greehouses with the district heating system. The owner plans to build 45,000 square feet of greenhouses per year and presently is using an old geothermal well.

In order to provide a more reliable service, Susanville is planning to drill additional wells to serve as backup. Pump or well problems could leave customers out in the cold. However, most of the retrofitted buildings have kept their conventional heating equipment. Susanville has no responsibility for retrofitting; users are responsible for secondary piping and all necessary equipment from the property line on. A revolving loan fund with low interest loans is being considered to finance residential system retrofits. Grants may be available for those families with financial difficulties.

Susanville uses Btu meters to measure usage and geothermal energy is priced at two thirds the price of No. 2 fuel oil. Susanville would like to get away from tying the price of geothermal to fossil fuel. They prefer to approach the price of geothermal based on a pay-

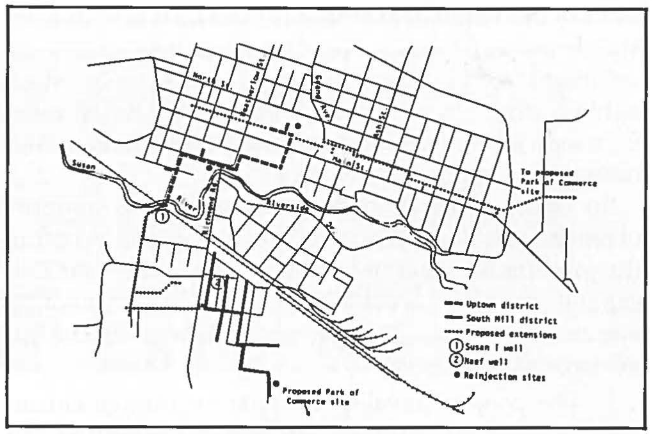

Figure 9
Susanville District Heating
(Gordon, 1983)

back of operational costs, depreciation and future expansion of the system.

Many of the customers are skeptical about the new geothermal system and want to see it work before connecting their buildings. Retrofit costs are also an obstacle to new customers connecting to the system.

The Litchfield Correctional Center, about eight miles from the City of Susanville, has been using about 750,000 gallons of fuel oil annually. Two geothermal production wells were completed to a depth of 1,500 feet and produced 1,500 gpm of 180°F fluid. The wells were developed by the city, through its private developer, Litchfield Developers, at a cost of approximately $960,000. Litchfield Developers will own and operate the system for 13 to 15 years with hand over to the city at no cost at the end of this period.

By contract, the city through Litchfield Developers, is obligated to supply the Center with a minimum of 60 billion Btu's per year. This displaces approximately 500,000 gallons of the 750,000 gallons of fuel oil presently consumed annually by the Center. Peak demand at the Center requires 1,000 gpm at 180°F and is disposed of through a sprinkler system covering 11 acres. Litchfield Developers and the city will initiate a marketing effort to attract an industry to utilize the cascaded energy from the system (City of Susanville, 1983).

Summary and Conclusions

Geothermal resources are fairly abundant, particulary in the western states, and development of these resources has been successful in providing a source of energy for district heating. Hydrothermal resources need to be located near the potential district heat loads and most of the successful projects are in areas where geothermal energy has long been used for direct heating purposes.

The characteristics of the projects discussed indicate that a reasonable resource temperature (perhaps 170°F) and a high utilization of the energy available (i.e. a large temperature drop) are critical for project success. A reasonable district heating size (perhaps 30 billion

Btu's of delivered heat annually) and heat load density are desirable to keep the costs per unit of energy delivered competitive with conventional fuels. Alternatively, the "spent" geothermal fluid can be cascaded for use in lower temperature applications (e.g. greenhouses, swimming pools, etc).

Six of the seven projects received varying amounts of federal funding which was instrumental in initiating the projects for most of the cities. Given the risks and expense involved with a geothermal district heating system, project success appears to depend on the following characteristics:

1. The project developers must encourage citizen interest and support, for citizen opposition can delay a project indefinitely. Potential customers need to be provided information about the risks, customer assistance for retrofits, and tax credits available to them if they utilize geothermal energy. The residential federal energy tax credit is 40%, up to a maximum of $4,000. There is no ceiling on the 15% business energy tax credit. In addition, some states also have renewable energy tax credits.
2. Geothermal energy must be priced high enough for the investor to make a profit, but low enough to encourage potential customers to switch off conventional fuels and to save a significant amount of money net of their retrofit costs. In most of the projects reviewed here, geothermal energy was priced at 50 to 70% of the natural gas or oil price. In one case involving a private investor, a pricing scheme was designed to cover operating expenses and provide a 15 to 20% return on the investment.
3. Flow meters in constant supply temperature installations are preferred because they provide an incentive for customers to maximize the temperature drop per gallon of fluid flow. With this type meter an economic incentive is provided to promote efficiency and conserve the resource, however it may reduce revenues of the system.
4. The type of contract, or user agreements, that are drawn up between the system and the user has important implications for financing. The district heating systems which utilize contracts include prices or pricing schedules in their agreements. Several of the projects do not require any contracts, and in most cases are free to quit the system at any time. On the other hand, none of the district heating projects have any commitment or obligation to deliver energy to their customers. Although none of the systems have failed after the final customer has signed up, this risk may be an obstacle to customers.

The seven projects described in this paper will provide a peak thermal power of about 71.4 MW_t at a capital cost of about $319/$kW_t$. This turns out to be one third of the cost of developing geothermal electric power plants.

In summary, experience at the seven geothermal projects indicates that low temperature geothermal resource can provide a reliable and economic source of energy for district heating systems. However, cities or private developers wishing to develop geothermal energy still face a number of obstacles. Legal clarification of their right to control water resources and local hydrology must be studied carefully before proceeding in order to avoid environmental problems. Cities willing to undertake these problems will find their efforts rewarded with a low cost, dependable energy supply which can spur economic development and provide energy savings to private citizens, businesses and municipalities.

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