A CENTURY OF SERVICE: THE BOISE WARM SPRINGS WATER DISTRICT SYSTEM

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INTRODUCTION

The use of geothermal and other renewable energy technologies is considered to be a relatively recent practice. There are examples, however, of visionary individuals developing alternate energy systems years or even decades ahead of most of the HVAC community. Geothermal district heating is one example with the first system established in Boise, ID, in 1892. Such early use of this now widespread resource is surprising. More impressive is the fact that this system is still in operation--a century later. It's success has spawned the development of 17 other geothermal district systems throughout the western U.S. and dozens more internationally. Interestingly, the pioneer developers of the Boise Warm Springs Water District system encountered the same issues we address today in district systems: marketing, rate structure, metering and hardware problems.

HISTORY OF THE BOISE WARM SPRINGS WATER DISTRICT

Boise was experiencing boomtown growth in the late 19th century due to the nearby gold discoveries and the city's location on the Oregon Trail. By 1890, it became evident that the growing city required a public water system to insure the community's health. The owners of the Overland Hotel received permission from the city to expand their system which had served the hotel and some of its neighbors for years (Worbois, 1982). Incorporating as the Boise Water Works, they announced a rate of $3.00 per month per faucet. At about the same time, a second group, the Artesian Water and Land Improvement Company also had its sights set on the local water contract. It was reported in March 1891, in the Idaho Statesman, that "hatred and strife" were rampant in Boise as a result of the battle between the two companies for customers (Worbois, 1982).

Throughout this period, a recent immigrant to the area, a Mr. Grumbling, had been regularly visiting the offices of two prominent local citizens, Mr. Hosea Eastman and Mr. William Ridenbaugh.

On each occasion, Mr. Grumbling attempted to convince the businessmen to invest in the drilling of hot water wells east of town. Mr. Grumbling insisted that conclusive proof of success existed. "It did not freeze around the spot in the winter, seemed warm near the surface and cattle had stepped in the soft earth never to appear again." (Harris, undated)

It is unclear whether these persuasive arguments (surprisingly similar to those presented by exploration geologists today) or other considerations prevailed; but, drilling was commenced at the hot springs shortly before Christmas 1890 (Wells, 1971). By March 1891, two 400 foot (120 m) wells had been completed which could sustain an artesian flow of 550 gpm (35 L/s) at 170°F (77°C)(Worbois, 1982). Mr. Eastman, as a director of the newly formed Boise Water Works (BWW), no doubt saw the value of hot water as a marketing tool. The fact that BWW could now offer hot as well as cold water gave them a decided advantage against their rivals at the Artesian Water and Land Improvement Company. In early 1891, BWW absorbed the opposing company and incorporated as the Artesian Hot and Cold Water Company (Wells, 1971).

It is interesting to consider that the development of the BWSWD might never have occurred had it not been for a single unemployed well driller pestering local businessmen to invest in hot water wells.

After completion of the wells, it was necessary to find a use for the hot water while the distribution lines were installed for the town. Having visited the recently constructed Natatorium in Helena, Montana, Mr. Eastman and fellow investors decided to have the same architect design a similar facility for Boise. A wooden pipeline was installed from the wells to the site of the new Natatorium on Warm Springs Avenue. The "Nat" opened on May 25, 1892 (Worbois, 1982). At 15,000 ft^2, the building included 50 bath and dressing rooms, a dancing and roller skating balcony, parlors, billiard rooms, card rooms, and cafe and bar. In addition, the $100,000 investment allowed for such unheard of (at the time) extravagances as electric ranges for those hosting a party (Worbois, 1982). The pool itself was 65 ft by 125 ft.

The wood-stave pipelines serving the "Nat" were also extended along Boise's Warm Springs Avenue to the downtown area so that nearby homes and businesses could be served. The "several miles" of pipe incurred a capital cost of $20,000 (Wells, 1971). With a calculated conventional fuel (wood and coal) savings in the area of $50,000, it appeared that the system was on the road to success. Marketing, however, proved to be more difficult than expected. Local building owners were wary of the new heating source and some were certain that either the flow or temperature would soon decline. To convince the public of the system's reliability, the homes of two prominent local citizens (and directors of the Artesian Company) were connected to the district in January of 1892 (Worbois, 1982). Numerous social functions were conducted during February and March in these homes and this along with the attractive rates of $2.00 per home per month (compared to coal at $7.00 per ton) soon began to attract new customers (Worbois, 1982). Within a few years, the system consisted of 4 1/2 miles (7.2 km) of large diameter distribution pipe and served 200 homes and 40 downtown businesses (Wells, 1971).

The construction of the Nat, the hot water lines and shortly thereafter a trolley line from downtown, transformed Warm Springs Avenue into Boise's finest neighborhood. In fact, the area became so well known early in the new century that comedian Will Rogers referred to it from time to time as "Hot Water Bottle Boulevard" (Harris, undated).

EARLY EQUIPMENT AND MATERIALS

As with any geothermal project, the heart of the Artesian Hot and Cold Water Company's system were the wells. Originally the system was operated with only the natural artesian head. It quickly became apparent, however, that more flow would be required to serve the growing customer demand. Additional wells were drilled but apparently did not increase the flow. At one point during the period between 1900 and 1912, an air-lift pumping arrangement, similar to that now used for testing wells, was attempted. Evidently, flow was increased but it was discovered that after four years of operation "the air had rusted out the metal pipes of the entire system" (Wells, 1971). As a result, in 1911 or 1912 two new 16" wells were constructed and equipped with 10" vertical turbine pumps and electric motors. As both of these pumps employed constant speed electric motors, cycling them on and off resulted in pressure surges in the system. To address this problem, a new pump and motor were installed in 1927. This pump was equipped with a variable speed, wound rotor motor (Figure 1). Of course, automatic controls were not yet available so a manual arrangement was concocted to provide system pressure control. The well house happened to be located adjacent to the Idaho State Penitentiary. Prison trustees were stationed, 24 hours per day, in the well house to operate the wound rotor motor. Employees of the Boise Water Corporation monitored a pressure gauge connected to the system downtown. When the pressure departed from acceptable limits, a call was placed to their supervisor. The supervisor then called the prison switchboard operator who contacted the trustees in the well house and advised them which way to adjust the pump speed. Although cumbersome, this control strategy remained intact until the 1970s (Griffiths, 1988).

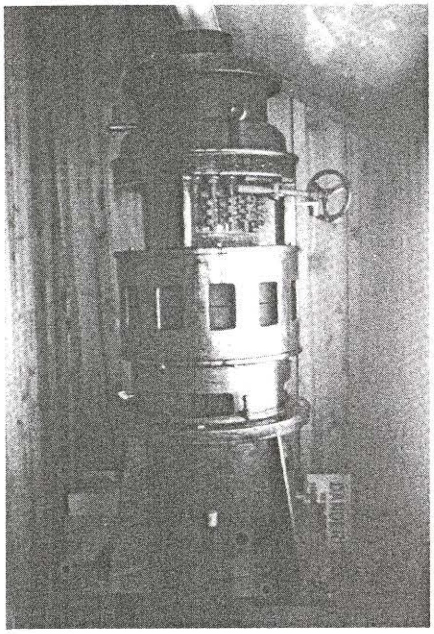

Figure 1. Pump equipped with variable-speed wound rotor motor, 1927 vintage.

New pumps were installed intermittently over the years (1935, 1943, 1954, 1962, 1987) in some cases as a result of failure due to cavitation caused by declining water levels (Rafferty, 1989). Reliability, however, has been very good due to the use of two wells throughout the system's history.

The well house for the system (Figure 2) was constructed by cutting off the tops of the original wood well drilling derricks and enclosing the framework. It is on the National Register of historic buildings.

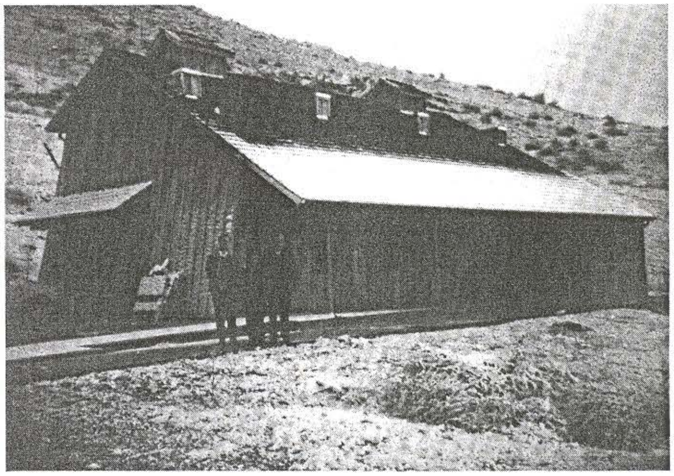

Figure 2. Original well house on the National Register of historic buildings.

Distribution piping for the water district has been constructed of a wide variety of materials. As discussed above, the first pipeline was of wood-stave construction. This piping was found to be "dangerous and useless" as early as 1896 (Wells, 1971). The early failure of the piping is curious as wooden piping in other geothermal systems has lasted for up to 70 years. The failure is most likely to have been related to corrosion of the iron bands rather than the wood pipe itself. The wood material was replaced about 1910 with an iron alloy pipe which employed lead and oakum connections. Some of those lines were insulated by constructing redwood boxes around the pipe and filling them with sawdust. Some of the redwood boxes were found intact as late as the 1980s (Griffiths, 1988). In many cases, however, the sawdust became saturated with water causing rapid failure of the pipe due to external corrosion (Straight, 1933). Many failures were also attributed to electrolysis which occurred when electric service was extended to the area in the early 1900s (Straight, 1933). In 1937, most of the main distribution lines were replaced with cast iron piping which served until 1982 when the entire system was replaced with asbestos cement piping. From the outset, the system has employed only a single line (supply only) distribution system. Waste water is disposed of in irrigation ditches, storm sewers and surface drains.

Several billing approaches have been used by the district. In the early days, a single flat rate of $2 to $3 per month was employed. Later, in an effort to get customers to conserve, water meters were installed. It is unlikely that hot water meters were available at that time and the cold water meters which were tried failed quickly. For most of its history, billing has been based on the use of orifice plates. A small orifice is place in each customer service line and a constant pressure maintained in the distribution system. Rates are based upon the size of the orifice with most homes using a 3/16 in. (5 mm) size (Griffiths, 1988).

The names of the entities operating the system have varied over the last 100 years from the Boise Water Works to the Artesian Hot and Cold Water Company to the Boise Water Corporation to the present Boise Warm Springs Water District (BWSWD). It's customer base fell somewhat during the late 1950s and 1960s when natural gas became available but rebounded after the 1973 energy crisis and currently 266 mostly residential customers are served (Rafferty, 1989).

MODERN GEOTHERMAL DISTRICT HEATING SYSTEMS

Although there were no large district systems installed for many years after the construction of BWSWD, individual building geothermal systems were widely used during the 1920s and 1930s throughout the western U.S. Competition from fossil fuels in the 1950s and 60s slowed development but growth returned after 1973.

The success and high visibility of the BWSWD system served as the catalyst for development of numerous other geothermal district systems both here and abroad. As of 1991, there were approximately 18 geothermal district systems in operation in the western U.S. (Figure 3). With one exception in 1963, all of these were developed since 1979.

Table 1 presents a summary of information on these systems.

Modern geothermal district heating (GDH) systems are charcterized by two general designs: open distribution and closed distribution. In the open distribution approach geothermal fluid is delivered directly to the customer where a heat exchanger isolates the building system from the geothermal fluid.

The closed distribution design employs central heat exchangers and a closed distribution loop of treated water to which customers can be directly connected. It is likely that most future district systems will be of the open design as this reduces total capital cost for the developer.

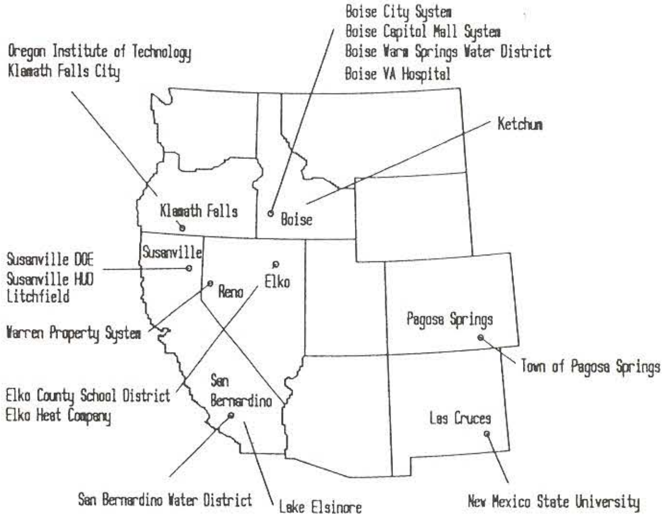

Figure 3. Location of U.S. geothermal district heating systems.

Table 1. Information Summary of Selected U.S. Geothermal District Heating Systems*

System	Location	Years Operated	Resources Temperature	Peak Flow (gpm)	Feet of Pipe
Oregon Institute of Technology	Klamath Falls, OR	27	192°F	980	7,300
Klamath Falls City	Klamath Falls, OR	6	210°F	1,000	14,000
Susanville, DOE	Susanville, CA	6	174°F	700	19,000
Susanville, HUD	Susanville, CA	5	155°F	300	10,000
San Bernardino Water District	San Bernardino, CA	6	138°F	3,700	35,000
Pagosa Springs	Pagosa Springs, CO	7	140°F	600	15,000
New Mexico State University	Las Cruces, NM	7	142°F	230	N/A
Boise City	Boise, ID	6	170°F	4,000	37,000
Boise Warm Springs Water District	Boise, ID	100+	176°F	1,600	11,300
Bosie Capital Mall	Boise, ID	7	169°F	750	6,000
Elko County School District	Elko, NV	3	190°F	290	11,300
Elko Heat Company	Elko, NV	7	170°F	650	15,500
Warren Property	Reno, NV	7	210°F	710	26,500

*Source: Rafferty, 1989

The design of most U.S. geothermal district heating systems can be divided into five or six subsystems. These subsystems include: production facilities, central plants (closed distribution systems only), distribution network, customer connections, metering and disposal. With the exception of certain materials considerations, the areas of distribution, customer connections, metering and central plants in geothermal systems are quite similar to their conventionally fueled counterparts. It is the production facilities and disposal subsystems which set geothermal district heating apart from district heating in general.

All operating systems tap low temperature (defined by the geothermal industry as <200°F [93°C]) resources and pumps are required to bring the water to the surface. Most systems employ lineshaft turbine pumps for this purpose. These pumps are similar to those used for irrigation. Modifications for geothermal service generally include enclosed oil lubricated lineshaft and bearings, special alloy bearings in the pump section, stainless steel fasteners and pump shafts. Depending upon the application, lengthened impeller housings may be required to accommodate shaft expansion. Electrical pumping costs for most systems are in the range of $0.10 to $0.35 per million Btu (0.034 - 0.12¢/kwh)(Rafferty, 1990).

Central plants are included in only those systems which employ closed distribution systems or about 40% of existing projects. Instead of boilers, these plants contain plate and frame heat exchangers to isolate the geothermal fluid from the distribution loop. These heat exchangers are generally assembled with 316 SS plates and medium nitrile rubber gaskets. Circulating pumps and controls are similar to those used in conventional systems.

Distribution piping for GDH systems is frequently of non-metallic piping. Due to the potential for corrosion and the relatively low water temperatures involved (130° - 200°F)(54° - 93°C) many alternative piping materials can be considered. To date, approximately 80% of all piping in these systems is non-metallic with asbestos cement pressure pipe the most common at 56% (Rafferty, 1990). In addition, smaller quantities of polybutylene, PVC and fiberglass piping are used. The lack of availability of asbestos cement pipe in the future requires that a different material be identified for new projects. At this point, it appears that ductile iron may fill this niche. It offers low cost, simple installation and eliminates the need for expansion joints and loops. Care must be taken, however, to avoid external corrosion from soil moisture or leaks.

Disposal is one of the major issues that distinguishes geothermal district heating systems from their conventionally fueled counterparts. Because of their heat source, geothermal systems are characterized by a large throughput of warm groundwater. Once the heat is extracted from the groundwater, it must be disposed of. In general, two methods are in use for this: surface disposal and injection.

Surface disposal consists of discharging the water to some surface feature, such as rivers, lakes, or percolation ponds. It is considerably less expensive than injection; but, it can lead to problems if a large number of users on the same resource employ the method. In two areas of the country where significant development has taken place (Boise, ID and Klamath Falls, OR), extensive use of surface disposal has resulted in measurable declines in the geothermal aquifer. As a result of these events and in the interest of resource conservation, many jurisdictions now favor injection as the accepted method of disposal. Surface disposal can also be limited by environmental considerations.

Injection is now practiced by 30% of the systems surveyed. Another 30% are in the construction or final planning stages of injection (Rafferty, 1990). In all cases, those systems planning injection are doing so in reaction to aquifer declines, regulatory pressures, or both.

Costs of injection wells are generally higher than for production wells on the same system. This arises from the increased geological and hydrological consulting services required. These services are typically employed in siting the well to help ensure that once in operation, the injected fluid does not simply "short circuit" to the production well. In addition, drilling techniques for injection must be more precise in order to accurately identify the geology of the well and to prevent damage to a potential receiving aquifer.

FUTURE PROSPECTS FOR GEOTHERMAL DISTRICT HEATING

Geothermal seems to be the quiet renewable resource. One of the major impediments to its future development is simply lack of awareness on the part of the public.

A quote from the April 2, 1892 Idaho Statesman Newspaper (Wells, 1970) is as true today as it was 100 years ago.

> "It is probable that people do not fully realize the value of the hot water that flows in such abundance from the artesian wells. It is understood in a general way to be a nice idea to have houses heated by such an agency; but, very few whose attention has not been called to the subject appreciate what the influence of this method of heating will be upon the future."

It remains true that most of the public are unaware of geothermal energy's contribution. Excluding heat pumps, there are approximately 300 sites in the U.S. where geothermal energy is currently in use for such applications as district heating, absorption refrigeration, aquaculture, greenhouse heating, industrial processes, snow melting and enhanced oil recovery. These projects currently supply 13.0 x 10^{12} Btu/yr (13.7 x 10^{12} kJ/yr)(Lund, 1990). In addition, geothermal electric power production now totals 2912 MW in the U.S.

Future prospects for the development of geothermal district heating systems are quite encouraging. By nature, operation of such systems displaces the use of conventional fuels and eliminates production of "greenhouse" gases such as CO_2.

In addition, the geographical extent of geothermal resources is quite significant. One study (Allen, 1980) identified a total of 373 western cities within 5 miles (8 km) of at least one hydrothermal site. Research has recently begun to refine these data.

California currently leads the nation in the development of new geothermal district heating systems. Using royalty funds from the operation of existing geothermal power plants, the state provides funding for feasibility studies and construction of new systems.

At present, the most likely areas for development are those states with known geothermal resources and a deregulated institutional setting for district heating development. This would include the states of Oregon, Washington, and California.

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