A City of Two Tales: Geothermal District Heating Times Two Elko, Nevada, USA

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ABSTRACT

Public ownership and operation or private ownership and operation — direct connection or indirect connection? These questions have been asked, and often hotly debated, for years by those engaged in the business of developing and operating geothermal district energy systems.

In few places in the world can the pros and cons, benefits and disadvantages of the different approaches to district energy development and operation be better evaluated than in Elko, Nevada, U.S.A. In Elko, we find a privately owned and operated district heating system built in 1982 that distributes geothermal brine directly to individual customers and a publicly owned and operated system built in 1986 that is based on isolating the distribution network from the geothermal brine through the use of a plate and frame heat exchanger. Both systems tap into the same geothermal reservoir.

Now, after some twenty years of operation, is it possible to pick a clear winner? The answer is not as clear as either side might imagine or desire, but the answer does provide important insights and possibly direction for future project development and system operation.

1. INTRODUCTION

Elko, Nevada provides a unique opportunity to study the unique differences that public versus private ownership and direct versus indirect distribution embody. Both geothermal district heating systems were built during the 1980's following the energy crisis of the 1970's. Now after over twenty years of operation, a close examination of the two systems identified a number of factors that have led to successful operation or resulted in operational problems. In addition, a number of system modifications were identified that would improve system performance of both systems.

2. RESOURCE

Elko County is located within the Basin and Range Physiographic Province. The distinctive features of this province are isolated, longitudinal fault-block mountain ranges separated by long, alluvial-filled basins. The city of Elko is located on the floor of one of these basins. The County's geothermal resources are located within the Battle Mountain Heat Flow High, as defined by Sass, et al (1971).

The area has been defined as a region of high heat flow where 90 to 150°C (194-302°F) resources are associated with deep fluid circulation along range front faults (Converse Consultants, 2002). The Elko area has a long history of geothermal water use and development, beginning with Native American use of the water at the "Hot Hole" in southwestern Elko. Continued use and reference to the Hot Hole and associated hot water springs was made by pioneers along the Oregon Trail in the 1840's. Development of the hot springs in the area provided for the old "Elko Home for the Aged", and subsequently the Elko County Association for Retarded Children used the area's hot water into the late 1970's (Converse Consultants, 2002). Review of the geologic literature suggests that there may be an extension of a fault or fault zone from the Sulfur Springs hot springs southwest of the city, which travels northwest through the community and intersects the Hot Hole and its associated springs as well as the geothermal high in the area of the Elko Jr. High School. Several geothermal wells have been drilled in the Elko area including the Elko Heat Company well which was drilled in 1982 to a depth of 265m (869 feet). Hot water at a temperature of 81°C (177°F) was encountered at approximately 215 m (705 ft.) (Therma Source, Inc., 1982). Robinson and Pugsley (1981) reported surface temperatures in the area ranging from 66-89°C (150-192°F) and geothermometers point to a resource temperature of from 80 to 114°C (176 - 237°F). A 572 m. (1,876 ft) well drilled adjacent to the Jr. High School in 1985 encountered 18.92+ l/s (300+gpm) of 88°C (190°F) water in the bottom 6-9 m. (20-30 ft) of the hole.

3. ELKO HEAT COMPANY

The Elko Heat Company district heating system (Fig.1) is one of two district heating systems in Elko, with the other being the publicly-owned system operated by the Elko School District. The system was initiated in 1978 when the United States Department of Energy, under its "Field Experiments for Direct Uses of Geothermal Energy" Program Opportunity Notice (PON), granted financial assistance for the development of a district heating system to serve the core business area of downtown Elko.

Original plans were to serve three large commercial customers, including an office building, a laundry (Fig. 2), and a casino/hotel complex (Fig. 3).

After completing resource assessment activities, a well was drilled in 1981 which was successfully completed to a depth of 265 m (869 ft.). The well was found to be capable of producing approximately 63.09 l/s (1,000 gpm) of 81°C or 177°F water from the primary production zone that lies at a depth of 258-259 m (845-850 ft.). The district heating system was completed and put online in 1982 at a total cost of $1,382,346, including $281,000 in customer retrofits. Of the total amount, $827,404 or 59.8% of the total was provided by the USDOE grant. Since coming online in late 1982 the system has grown appreciatively to include 19 consumers, and with gross revenues in 2001 of $184,267. The owners continue to attract new customers and the system appears to be capable of serving nearly double its existing load without the need for additional wells or central peaking.

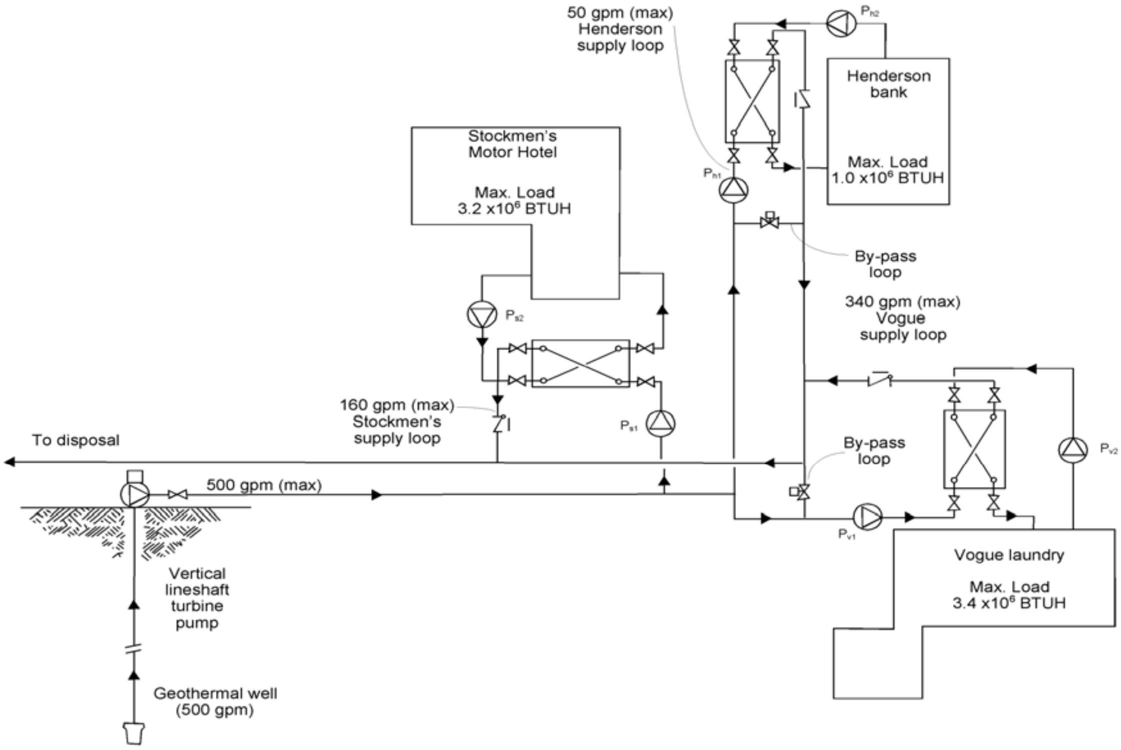

Figure 1: Elko Heat Company district heating system configuration

Figure 2: Vogue Dry Cleaners

Figure 3: Stockman's Casino

4. USE

Considering that the system was originally designed to serve only three primary customers, the success of the system in attracting new customers is noteworthy and highly commendable. The system now serves the Bank of America, Chilton Engineers (personal residence), City of Elko (STP), Elko Co. Detention, Elko Co. Court House (Meter #1), Wells Fargo Bank, Stockman's Casino and Hotel, Commercial Casino, Callagher Bldg., Thomas H. Gallagher (private residence), Henderson Investment Company, Ormaza Investor's, U.S. Post Office, Sierra Pacific Power, Vogue Laundry and Dry Cleaners, Western Folk Life Center, America High Votage, Ormaza Investor's Old Newmont Bldg. and Elko Court House (Meter #2) (Elko Heat Co., Customer File, 2003). These customers are served via a 2,852 m (9,358 ft.) distribution system of primarily asbestos concrete construction. Each customer is required by the Energy Connection and Service Agreement to provide his/her own backup heating system in order to provide energy service in the event that the geothermal system is shut down (Annual Report to the Nevada Public Service Commission, 1989). The distribution piping is insulated and jacketed. The return line is also of asbestos concrete construction; however, the return line is uninsulated. Piping runs from the distribution loop to individual consumers is 304 stainless steel using welded connections. Geothermal fluid at approximately 81°C (177°F) is circulated directly from the well head through the distribution system to each consumer. Each consumer, with the exception of the Vogue Laundry and Dry Cleaners, is connected to the system via a plate and frame heat exchanger of stainless steel construction. In the case of the Vogue Laundry and Dry Cleaner, the geothermal fluid (after softening) is used directly in the laundry. Geothermal fluid, after passing through the customer heat exchangers, enters the return line and is carried to the disposal facility. Disposal is via ponds used to cool the water and allow for some percolation, some water, once cooled, is allowed to flow to the Humboldt River.

Customers are billed on the basis of liters (gallons) used. Flow is measured via hot water, totalizing, multi-jet, turbine meters that are read each month. At present the rate is $1.50 per 3,785 liters (1,000 gallon). Originally the rate had been set at $1.15 per 3,785 liters (1,000 gallon). That rate was increased to $1.38 per 3,785 liters in 1992 (1,000 gallon) and to $1.50 in 2001 (Elko Heat Company General Information and Procedures, 2003). Two residential consumers (Mark Chilton and Thomas Gallagher) are charged a flat rate of $122.10 per month (Elko Heat Company General Information and Procedures, 2003). Total literage for 2000 was 25,208,140 (6,659,286 gallons), for 2001 15,861,352 (4,190,126 gallons) and in 2002 18,556,013 (4,901,980 gallons). The system is capable of providing approximately 25.23 l/s (400 gpm) under artesian conditions (i.e. to meet baseload requirements). Flow rates in excess of 25.23 l/s (400 gpm) require pumping to boost the pressure. Total system capacity is estimated at approximately 63.09 l/s (1,000 gpm) and with a 11.19 kW (15 hp) pump approximately 44.16 l/s (700 gpm) can be provided. Pumping is accomplished via 2 stage vertical turbine pump (line shaft turbine) equipment with a 11.19 kW (15 hp), 1,800 rpm motor. Although the system was originally equipped with sensors that would activate the pumping when pressure fell below 241 kp (35 psi), the automated controller was removed, and pump activation is now manual. The system appears to be capable of meeting the needs of additional consumers even in its present configuration, and could meet the heating needs of additional consumers through addition of pumping to increase flow to a peak of approximately 63.09 l/s (1,000 gpm), drilling of additional wells or addition of a fossil fuel peaking unit. The addition of a fossil fuel peaking unit would, from the author's experience, appear to provide the greatest near term as well as future benefit as it would allow not only for expansion of the system to new customers but would also provide backup to the existing geothermal wells and thus eliminate the need for in- building backup/peaking equipment.

5. OPERATING COSTS

Based on the latest figures available (2001, Elko Heat Company, Public Utilities Commission and Accountant's Compilation Report) the operating revenue for 2001 was $184,. Total operating expenses were $47,840 or an increase of $4,465 from the previous year. Maintenance of the system accounted for an expenditure of $19,105 while contract services and materials accounted for $22,135. (Elko Heat Company General Information and Procedures, Jan. 2003).

6. PROBLEMS AND SOLUTIONS

The project has experienced ongoing problems associated with corrosion of various components of the distribution system. Initially, customer branch piping consisted of carbon steel lines running from the main asbestos concrete distribution lines. Several failures, including one inside the customer building, resulted in a requirement that all new customer branch lines be constructed using 304 stainless steel. There were also corrosion problems associated with carbon steel service saddle components. The current practice is to use stainless steel bands (Elko Heat Company, 2003, Personal Communication).

Other system components have also failed due to corrosion related issues, and in 1997 the Elko Heat Company reported the need to replace several components due to corrosion failure, including ductile iron valves, fittings and steel bolt up hardware (Lattin, 1997). In 1999 Converse Consultants submitted a metallurgical report to Elko Heat Co. that detailed a number of corrosion related issues, probable cause for corrosion and recommendations for further action (Converse Consultants, 1999).

Converse concluded that corrosion was probably caused by geothermal water leaking into or in contact with various metal components. The geothermal water contains about 17 ppm of chloride ions and 75 ppm of sulfate ions. Hydrolysis involving chloride and sulfate ions is expected to have increased acidity of water and resulted in a pH of around 4.0 or lower. Such acidified water in confined regions, e.g. in the annular region of flanges, or under corrosive residues, or in the soil encasing system components, e.g. valves can chemically react with susceptible components and result in harmful corrosion. Converse further concluded that if water could not be kept away from susceptible components, then it would be necessary to install structural materials that can resist deterioration by corrosive waters better than Type 304L stainless steel. Recommended materials included 310L, Monel and Titanium. It was also noted that galvanic corrosion was also a factor with certain components and that cathodic protection should be provided.

The only other major problem occurred with the direct use of geothermal fluid through one customer's existing heating system (Elko Heat Company, Personal Communication, 2003). That customer subsequently left the system due to high rates of corrosion.

ELKO COUNTY SCHOOL DISTRICT

The Elko County School District system is the other district heating systems in Elko (Fig. 4). In 1985 the School District had originally planned to drill a well to encounter low temperature geothermal resources that could be used for a geothermal heat pump system for the Junior High School (Fig. 5).

However, when the well, drilled to. 572 m (1,876 ft) encountered significant flows of 88°C (190°F) geothermal water, a decision was made to serve all of the school district facilities in Elko as well as a number of additional public buildings, including the hospital and Convention Center (Fig. 6), through the construction of a district heating system The School District is at present in the process of determining the feasibility of expanding the system to serve a number of buildings on the Great Basin College Campus (CBC).

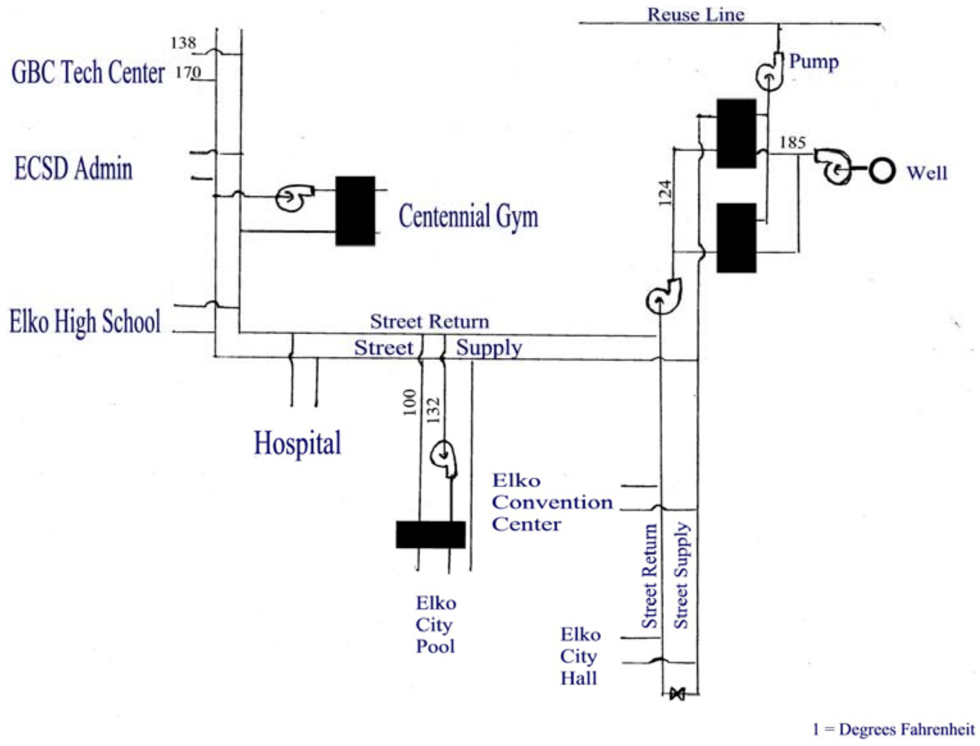

Figure 4: Elko County School District Geothermal System Layout

Figure 5: Elko Jr. High School

Figure 6: Elko Convention Center

7. USE

The Elko Jr. High School well provides heat to serve 16 public buildings through 11 interconnections. The buildings served include Elko Jr. High, the Convention Center, City Hall, City Pools (pool heating), City Pools (space heating), the hospital, Elko High School Vocational, Elko High School (six buildings), and the Centennial Gymnasium (including central kitchen building) central office building (includes service and maintenance building and warehouse). The total building area is 32,393 sq. m (348,680 sq ft.) of which 28,333 sq. m. (304,971 sq ft) is heated geothermally. Estimated peak geothermal flow is 19.49 l/s (309 gpm) with a peak heating load of 3,136 kW_t (10,708 kBtu/hr). The average delta T is approximately 19.3°C (34.8°F) with a peak delta T of 24.2°C (43.5°F). Two of the connections are to the return loop, including the pool heating portion of the City Pool's heating load, and Elko Jr. High's heating load is also served from the return loop. The Elko Jr. High domestic hot water heating load is served with geothermal fluid directly from the well side of the geothermal heat exchanger.

The geothermal fluid from the geothermal well is transferred to a secondary circulating loop at the Jr. High School via a plate and frame heat exchanger for space heating. Discharge from the system is 43-60°C (110-140°F) and goes to holding ponds and eventually to the Humboldt River. The circulating loop is welded steel pipe, insulated and jacketed. Each building is connected to the circulating loop via a plate and frame heat exchanger. Each consumer is required to provide their own backup/peaking capability.

Recently a new building on the Great Basin College (CBC) campus was connected to the system and raised concerns as to whether or not the system was adequate to meet the needs of the new customer as well as additional buildings on the CBC campus. The expansion to the 5 existing buildings on the campus would result in an increase in the peak demand of approximately 715 kW_t (2,440 kBtu/hr) and an increase in peak flow of 7.70 l/s (122 gpm). Preliminary analysis done by the Washington State

University Energy Program indicates that the system would be inadequate as it is now configured to meet this additional load without significant capital improvement. Several alternatives were identified, including increasing the diameter of some piping runs, installing a booster pump within the distribution loop or installing a peaking boiler. The installation of a peaking boiler would result in a more robust system, minimize the need for customer backup systems and also reduce peak flows and associated disposal issues.

8. OPERATING COSTS

Cost of operating the system is covered by an annual $5,000 assessment to each of the four entities that receive service from the system. Individual entities, however, must cover any costs that may be required related to their equipment operation, maintenance, repair or replacement. Additional or special assessments may be levied to cover system costs in excess of the $20,000 or when possible such costs may be covered by funds held in a reserve fund created for that purpose. Savings to the four entities are estimated to exceed $250,000 per year and in 2002 exceeded $285,000 (Elko School District, Personal Communication).

9. PROBLEMS AND SOLUTIONS

The system has experienced few real problems since being put online in 1985, with the exception of one pipe break as a result of external corrosion. This could unfortunately also result in additional problems in the future. Although major problems have not plagued the system, there appears to be little overall system management or coordination, and various entities having essentially free rein to connect as they please. This has resulted in some minor but potentially major problems as when the pool system was connected and when booster pumps were installed, they actually tended to pressure the return line in a reverse direction. The only other problem is how to meet continued desire to expand the system given restrictions on disposing additional fluids. The only reasonable approach would be to install a fossil fuel peaking system. This would also provide backup and negate the need for individual customers to provide their own backup.

10. CONCLUSION

The Elko Heat Company and the Elko County School District geothermal district heating system have operated since the early to mid 1980's. Both systems have operated extremely successfully despite their differing ownership, structure, and design philosophies. Both systems have been economically viable and have resulted in significant savings to end users.

The privately owned and operated Elko Heat Company system has exercised greater control over end use connections than has the publicly owned and operated Elko County School District system and as a result has experienced fewer problems related to customer connections. The School District system, because it does not distribute geothermal water directly, has as would be expected, experienced few distribution system problems due to corrosion or scaling, while the Elko Heat Company system has experienced extensive problems related to corrosion and scaling due to the direct distribution of geothermal flushes. Both systems could benefit from the ability to provide peaking and back up from a new geothermal source and both will face increasing pressure to limit surface disposal or be forced to inject.

But is there a clear winner when it comes to the question of ownership or distribution—not really. Both have their strong points and both will continue to have their advocates. But both could learn something from the other.

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