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GEOTHERMAL DEVELOPMENT IN ELKO, NEVADA — PROJECT SUMMARY

By James Meeks* and Michael W. Lattin**

Resource Description

The Elko Heat Company project will utilize low-temperature [less than 93°C (200°F)] geothermal fluids from the Elko resource area. This area has been classified as a Known Geothermal Resource Area (KGRA) by the U.S. Geological Survey (USGS). The existence of the resource has been recognized in Elko for many years (as far back as the late 1800's). There are a number of surface expressions located in the southwest portion of the city. In the past, utilization of the resource has been limited to heating a spa (late 1800's and early 1900's), source of water for the Elko Municipal Swimming Pool until 1950, use as domestic hot water on a limited basis, and more recently, use as a heat source for a greenhouse growing a variety of vegetables.

These uses are employing one of the three surface expressions of the resource or shallow underground flow related to the surface expression.

The extent and location of the resource at depth had never been defined. In the past when drilling penetrated the hot underlying strata, drilling was stopped and the hole either plugged at the bottom or abandoned. Most of the drilling activity was in the search for supplies of cold water and every effort was made to avoid the geothermal resource.

The Elko Heat Company project has made the first attempt to locate and define the underlying geothermal resource. This investigation consisted of running a series of shallow temperature gradient holes, geologic fault mapping of the area, and electrical resistivity and electromagnetic surveys. The work was completed by Geothermal Surveys, Inc. (GSI) from Pasadena, California.

The next phase of the resource assessment consisted of drilling four test holes to depths between 183 and 335 meters (m) [600 and 1,100 feet (ft)]. These test holes exhibited the expected abnormally high downhole temperature gradient. What was considered the best test hole was abandoned at approximately 183 m (600 ft) after the drill rig tipped over. The decision was made to attempt drilling a production well at this location.

The production well was completed in August, 1981, and was successful in tapping the resource. The well encountered what is reported to be a faulted fractured zone at 259 m (850 ft) which produced a geothermal fluid with a temperature of 82°C (180°F). The well was artesian and flowed at over 31.5 liters per second (l/s) [500 gallons per minute (gpm)] with a shut-in pressure of 352 kilopascals (kPa) [51 pounds per square inch (psi)]. Flow from this well appears to be controlled by a complex faulting system.

Testing of the well has confirmed a reservoir of large capacity and proven reliability after more than 50 days of flow testing under artesian conditions.

It is felt that in the future additional wells can be completed and the capacity of these wells could be greatly increased if desired.

The water quality of the geothermal fluids from the Elko resource is excellent

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and meets state and federal requirements for drinking water. The type of fluid is indicative of a shallow and low-temperature resource. The water quality analysis is shown in Table 1 below:

TABLE 1
ELKO HEAT COMPANY
PRODUCTION WELL NO. 1

WATER QUALITY ANALYSIS
Results in mg/l

CONTAMINATE	SAMPLED 12/1/81
Arsenic	0.0078
Barium	0.78
Cadmium	0.0002
Chromium	0.0021
Flouride	1.8
Lead	0.0010
Mercury	0.0001
Nitrate (As N)	0.05
Selenium	0.001
Silver	0.0002
T.D.S.	606
Hardness	214
Calcium	61
Magnesium	12
Sodium	117
Potassium	47
Sulfate	77
Chloride	16
Alkalinity	405
Bicarbonate	378
Carbonate Hydroxide	2
Iron	.26
Manganese	01
pH	6.7 units
Silica	59.2
Lithium	0.35

Project Objectives

The Elko project is intended to demonstrate the feasibility of utilizing geothermal energy in a district heating type of application. The technical and economical feasibility will be demonstrated by three initial consumers utilizing the heat in three different conceptual heating applications. The Vogue Laundry, a commercial linen supply business, will utilize the water directly for wash water after softening. The Stockmen's Motor Hotel, a hotel/casino complex, and the Henderson Bank Building, a four-story office complex, will utilize the water for space heating and heating of hot water.

The Stockmen's Motor Hotel will utilize a heat exchanger to heat a closed hydronic loop. The Henderson Bank Building will circulate the geothermal fluids directly through either the existing radiator system or the existing fan coils (presently utilized for building cooling). The planned system will displace 100 percent of the Stockmen's and Henderson's space heating and hot water requirements. Both systems are designed to take 74°C (165°F) (minimum) water and discharge 46°C (115°F) resulting in a 28°C ΔT (50°F ΔT).

The Vogue Laundry will utilize the geothermal fluid in place of existing city water supply, thus eliminating the need for heating city water at a temperature of between 13° and 16°C to 71°C (55° and 60°F to 160°F.

The retrofitting of these three users results in approximately 25,000 million Btu's of conventional fuel being displaced. The displaced fuel is primarily natural gas which presently costs $5.20/ million Btu's. The building retrofitting design and construction is the responsibility of the end user. Elko Heat Company is committed only to provide geothermal fluid at the 74°C (165°F) minimum temperature and at the quantities required by the end user.

It is anticipated that the end users will be on-line by the fall of 1982. One year of monitoring of the system will take place at this time to determine the system efficiency.

Special Investigations

Elko Heat Company has been involved in a number of tests and studies to confirm the reliability of the existing production well and to assist in materials selection for final design.

These tests included 50 days of flow testing to monitor reservoir performance, temperature, pressure and water quality, operation of a prototype heat exchanger, and corrosion and scaling tests. The flow tests were run not only to determine the capabilities of the Elko Heat Company well but also to study the potential for interference with other geothermal wells and springs in the area. There was no evidence of interference with these sources.

The long-term flow tests were valuable in confirming the resource reliability and determining potential interference with other sources. During the flow test a leak in the well bore was located that was successfully sealed off at a later date. It was also noted that the temperature fluctuated, depending on rate of flow and duration of flow, between 78° and 81°C (173° and 178°F). It is felt this temperature fluctuation was related to the leak in the well bore.

All test results to date indicated that the fluid is very "mild" and no special problems in materials selection are anticipated. One factor encountered was that system pressures have to be maintained above 69 kPa (10 psi) to keep the carbon dioxide gas in solution to avoid bicarbonate ion precipitating out as calcium and magnesium carbonate.

System Design

The geothermal energy distribution system has been designed and was scheduled to go out to bid during the month of July, 1982. The estimated cost of the system is $525,000. The wellhead equipment consists of a deep well line shaft pump set at 45.7 m (150 ft) and equipped with a variable speed drive, miscellaneous piping and valving, and a pump building.

The wellhead system operates under artesian flow conditions up to 12.6 l/s (200 gpm) and under pumped flow at ranges between 12.6 and 37.8 l/s (200 and 600 gpm). The system is controlled by sensing changes in pressure in the discharge piping.

The distribution system consists of 1219 m (4,000 ft) of 25.4 centimeter (cm) [10 inch (in.)] and 20.3 cm (8 in.) diameter asbestos-cement supply and return pipe. Approximately 609 m (2,000 ft) of the supply pipe will be insulated "Temptite" pipe to avoid excessive temperature losses due to ground moisture conditions. The remainder of the system is uninsulated.

The system provides for conveying high-temperature supply water [74°C (165°F) minimum] to the initial users who will either utilize the water directly or extract heat and dispose of the reduced temperature water in the return line. In the future, an effort will be made to "cascade" [to find users with lower temperature requirements who could use the 38° to 43°C (100° to 110°F) return water directly or in combination with a heat pump system].

The return fluids will eventually end up in a surface disposal pond where cooling will be provided through a spray nozzle system with the water either used by the city of Elko for irrigation or disposed of by infiltration/percolation.

Figure 1 (following page) shows a schematic diagram of the piping and valving arrangement in the pump building.

Legal and Procedural

The project as designed required an agreement between the city of Elko and Elko Heat Company to provide a pond for the disposal of spent fluids. The city of Elko was very cooperative in allowing Elko Heat Company to build this pond on their property. Disposal of spent fluids was a serious project concern and this agreement resulted in a relatively simple solution to the problem.

The question of water rights resulted in significant project delays. Under Nevada law, a well cannot be drilled in the Elko ground water basin without first obtaining a permit from the state engineer. When the well location was finally confirmed, it was decided to accept a permit that contained terms calling for reinjection of spent fluids to the "source" or a non-consumptive use of the water.

The final design required a consumptive use of the fluid and, therefore, a change

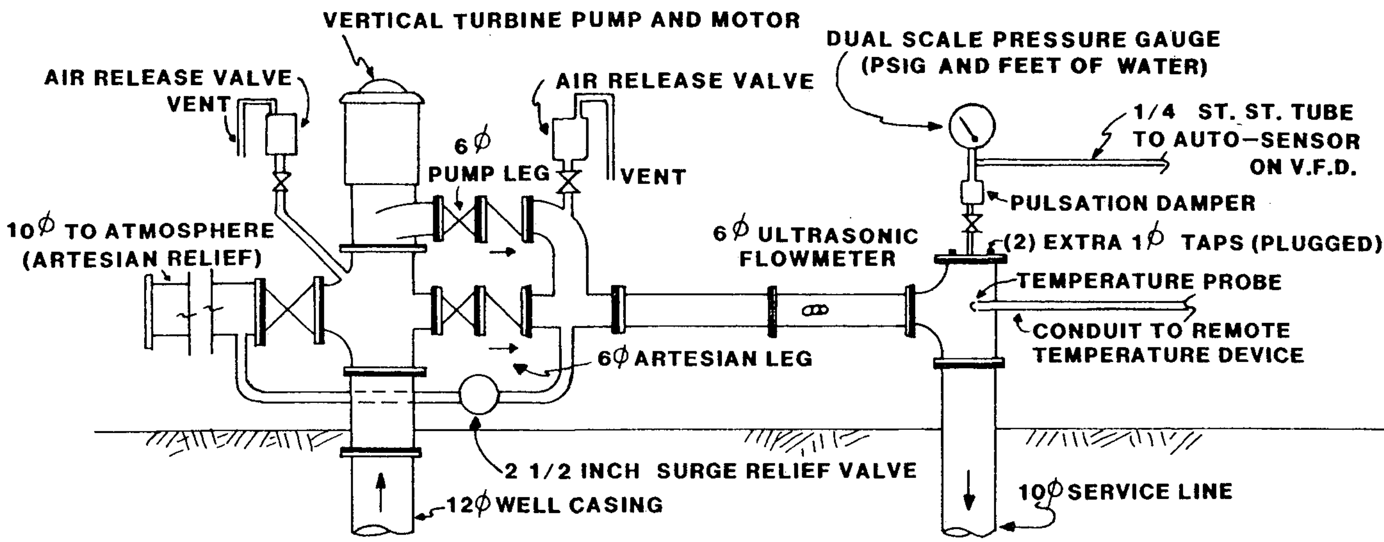

Figure 1. Equipment at Wellhead.

in the permit terms. The change to a consumptive use has been before the state engineer who was expected to rule on the matter sometime in July, 1982. The flow testing and monitoring program was utilized by Elko Heat Company to support the requested change.

It was necessary to acquire permission from the city of Elko, Western Pacific Railroad and Southern Pacific Transportation Company to construct facilities on their land and/or in the vicinity of their facilities. The distribution pipeline and return pipeline crosses railroad tracks in four locations.

The decision was made to initially develop the system as a user-owned utility to avoid the requirement of being regulated by the Nevada Public Service Commission. In the future, as the system expands, it will become necessary to organize as a public utility in order to provide service to a broader customer base.

Current Estimated Project Cost

The current cost estimate for the Elko Heat Company project is illustrated in Table 2 (following page). At the bottom of this table, funding is broken down according to participation of Elko Heat Company and the U.S. Department of Energy.

Lessons Learned

Project permitting and licensing requirements should be fully investigated and evaluated early in the project. This project has encountered difficulty in securing adequate water rights and in developing an acceptable plan for disposal of spent fluids.

After developing and securing an adequate resource, the question of disposal of spent fluids is the next most important question. Disposal alternatives considered included:

1. Reinjection to geothermal aquifer.
2. Disposal by infiltration/evaporation.
3. Discharge to local receiving water.
4. Treatment and reuse as potable water.
5. Reuse as agricultural or industrial process water.
6. Discharge into sanitary sewer system.

TABLE 2

ELKO HEAT COMPANY
TOTAL ESTIMATE PROJECT COST
ELKO GEOTHERMAL ENERGY PROJECT

I.	ENVIRONMENTAL REPORT		$ 12,235
II.	RESOURCE ASSESSMENT		164,139
III.	PRODUCTION WELL DRILLING		150,000
IV.	CONCEPTUAL DESIGN		58,036
V.	FINAL DESIGN		93,000
VI.	PROTOTYPE HEAT EXCHANGER TESTING		4,579
VII.	CONSTRUCTION MANAGEMENT		50,000
VIII.	SYSTEM FABRICATION		
	Pumphouse and production well equipping	$ 70,000	
	Distribution System	410,000	
	Effluent Disposal System	55,000	
	Building Retrofitting	281,000	
	TOTAL CONSTRUCTION:		$ 816,000
IX.	MISCELLANEOUS COST, PERMITS, LAND AND RIGHT-OF-WAYS, LEGAL EXPENSE, ETC.		96,000
X.	FINAL PROJECT MONITORING AND EVALUATION		21,445
	ESTIMATED TOTAL PROJECT COSTS:		$1,465,434
	DOE FUNDING AVAILABLE		$ 827,524 (56%)
	ELKO HEAT COMPANY FUNDING		$ 637,910 (44%)

Because of the relatively good quality of the geothermal water, a combination of alternatives 2 and 5 was selected.

The design of geothermal wells in unknown fields must be based upon sufficient data to insure proper construction. Elko Heat Company completed a well that was leaking hot water into a shallow cold water aquifer. Had it not been discovered, this condition could have resulted in a warming of the cold water aquifer and/or the development of springs or seeps in the vicinity of the well.

This leakage was occurring at a depth of 74 m (242 ft) where a 20.3-cm (8-in.) diameter liner was hung inside a 30.5-cm (12-in.) diameter casing. This joint was sealed by "squeezing cement" in the annulus. This type of repair was very expensive, risks losing the well, and results in the project being delayed.

Another problem encountered in the construction of the Elko Heat Company well was that the original design called for open hole completion from 165 to 260 m (542 to 852 ft). The production zone was determined to be located between 257.5 and 259 m (845 and 850 ft) depth. The formation from 165 to 244 m (542 to 800 ft) was unstable and bridging or plugging occurred in this area. This required installation of a 15.2-cm (6-in.) diameter blank liner from 74 to 250 m (242 to 820 ft).

Prior to completing a well in unknown fields, a pilot or test hole should be drilled to determine formation types and whether or not the well will be artesian. If artesian conditions are present the nonproductive formations encountered should be cased and cemented. After completion of the well; flow testing, temperature and spinner loggings should be done. All unstable formations should be cased and perforated casing or well screens installed in the production zone if necessary.

Another lesson learned is that it is very difficult to estimate project cost prior to determining the resource location. Elko Heat Company anticipated drilling a well within 152 m (500 ft) of the end users, but the well that was completed ended up over 914 m (3,000 ft) away from the nearest user which resulted in a considerable increase in project cost.

Summary

Because of the unknowns associated with this type of system, both cost estimates and time schedules have been under continual revision. There are many factors that influence the development of this type of system. The Elko Heat Company system has progressed to a point that the board of directors are now confident that the project can be completed in accordance with the original project objectives.