NEVADA GEOTHERMAL UTILITY COMPANY: NEVADA'S LARGEST PRIVATELY OWNED GEOTHERMAL SPACE HEATING DISTRICT

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ABSTRACT

Since the early 1980's Nevada Geothermal Utility Company has provided space heating and domestic hot water to homes in a southwest Reno neighborhood. The system not only heats 110 homes, but also provides heat for domestic hot water, heat for 21 swimming pools, seven hot tub spas, and one driveway de-icing. Four wells have been drilled for production and injection of geothermal fluids. Two wells, WE-1 and WE-2 are the geothermal supply wells. Well WE-3 serves as the primary injection well. Geothermal fluid at a temperature near 200˚F (190-205˚F) is pumped from production well WE-2. The 40 hp turbine pump supplies the pressure to force the geothermal fluid through the flat-plate heat exchangers and down the injection well. Customers currently pay 75% of the price of natural gas for space and hot water heating. A comparison of homes heated with natural gas and homes heated with geothermal energy show a savings between 17 and 22 percent for homes heated with geothermal energy.

BACKGROUND

Nevada Geothermal Utility Company (NGUC) was incorporated in Nevada on April 20, 1981. On March 11, 1983, the public service commission of Nevada issued Geothermal Operating Permit (GOP-001) to Nevada Geothermal Utility Company for a geothermal space-heating district. From its humble beginnings in 1983 using a down hole heat exchanger to heat 10 homes to the present, where one production well supplies 400 gallons per minute (gpm) during peak load. The system not only heats 110 homes, but also provides heat for domestic hot water, heat for 21 swimming pools, seven hot tub spas, and one driveway de-icing.

The space-heating district is located in southwest Reno, in what is known as the Moana geothermal resource area. A hot spring, known as Moana Hot Springs, was the site of first use of the geothermal resource in a swimming pool in the early 1900's. Several hundred homes, three churches, and a nursery, in addition to NGUC, currently use geothermal fluids from this resources for space and hot water heating.

Mr. Frank Warren, a real estate developer from southern California, envisioned heating homes with geothermal energy and was instrumental in providing the impetus for development of the space-heating district. The first phase of the heating district consisted of a 60 home subdivision known as Warren Estates. The first homes in this subdivision used hot water heated by geothermal fluid to heat their homes and supply hot water in 1983. The second phase of the district heating system is known as the Manzanita Estates and was developed in 1986. It consists of 102 lots supplied with geothermally heated hot water. The subdivisions had all utilities including electrical, water, gas, phone, sewer and cable installed underground. Since geothermal heating was the new kid on the block it was relegated to the bottom of the trench.

GEOTHERMAL RESOURCE

The original Moana Hot Springs were centered in the NE ¼ of section 26, T19N R19E. The area of known elevated temperature in the near surface covers an area of approximately 3 square miles. The area extends from the intersection of Plumb Lane and Virginia Street in the northeast, south to South McCarran Blvd., then west to Skyline Blvd., as shown in Figure 1.

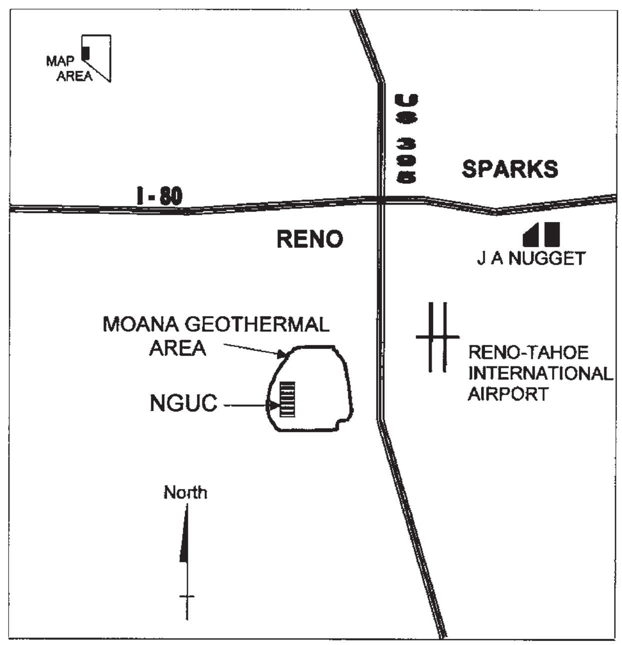

Figure 1. Sketch map of Reno-Sparks showing Nevada Geothermal Utility Company (NGUC) service area and the Moana Geothermal Area (not to scale).

Bateman and Scheibach (1975) studied the Moana geothermal resource. They canvassed the known users of the resource and determined that at the time of their study 35 homes were heated with the geothermal energy. Most used individual wells with a down hole heat exchanger, a U-shaped tube inserted in the well, in which municipal drinking water was circulated. The heated water was then pumped through baseboard radiators or forced air systems to heat the homes. Well depths ranged from 100 to 500 feet. Wells with the highest temperatures (210˚F) are associated with a series of north-trending faults zones. Garside and Schilling (1979) provide a general overview of the geology and geothermal resources of the area. A more detailed description of the controlling geologic factors and description of the resource are provided by Flynn and Ghusn (1984).

In the vicinity of the Warren Estates wells, the geothermal reservoir appears to be associated with a highly permeable fracture zone. Flynn (1985a) characterizes the zone, which was intercepted in both production wells, as being a highly porous and permeable intravolcanic flow breecia of the Kate Peak formation. The Hunter Creek sandstone, a sedimentary sequence consisting of sands, gravel, conglomerate and a thick section of diatomaceous siltstone overlies the Kate Peak formation. It is Miocene to Pliocene in age (approximately 24 to 1.8 million years old) and varies widely in thickness and composition from place to place. Locally alluvium and glacial outwash overlie the Hunter Creek sandstone.

GEOTHERMAL WELL FIELD

Four wells have been drilled for production and injection for Nevada Geothermal Utility Company's system. The wells are located in the SW1/4 NW1/4 section 26, T19N R19E M. D. B. & M.. Two wells, WE-1 and WE-2 are the geothermal supply wells. Well WE-1 also serves as a supplemental injection well. Well WE-3 serves as the primary injection well and is permitted to receive a maximum of 300 gpm of the produced geothermal fluids. Well WE-4 was drilled in 1995 as an injection well; however, it does not produce or accept sufficient quantities of fluids and is currently inactive.

WELL WE-1

This was the first well drilled as part of the geothermal space heating system. It is located at the brick building, which houses the heat exchangers. The well was drilled in April 1982 to a depth of 833 feet. It had a bottom hole temperature of 201˚F. The static water level was 100 feet below the surface. Initial flow testing indicated that the well could be pumped at 450 gpm with 35 feet of drawdown after 17 hours.

WELL WE-2

This well was drilled in 1985 to support the expansion of the new subdivision (Manzanita Estates). The well was drilled to a depth of 685 feet. Cuttings indicated that alluvium and the Hunter Creek sandstone occurred to a depth of 300 feet. Below the Hunter Creek there are approximately 300 feet of hydrothermally altered Kate Peak formation ("blue clay"). Unaltered Kate Peak formation was encountered below the "blue clay" at 600 feet. At 615 feet a fracture zone was encountered and lost circulation occurred to 645 feet. The temperature at the bottom of the hole was isothermal at 210˚F. The hole was reamed to 17-1/2 inches to 604 feet and 12-inch casing was cemented in place to this depth. The static water level after equilibrium was 105 feet below the surface (Flynn, 1985a). A 72-hour pump test was performed in late June 1985. The average flow rate was 865 gpm. Maximum drawdown during the test was 45 feet. Pump test data yield transmissivity values of 22,690 gal/day/ft and a storage coefficient value of 0.00105 (Flynn, 1985a).

WELL WE-3

Well WE-3 was drilled in 1985 to a depth of 1,475 feet as an injection well. Drilling encountered alluvium, Hunter Creek sandstone, siltstone and blue clay to a depth of 1,040 feet. Kate Peak formation, with numerous lost circulation zones at 1,195, 1,345 and 1,460 feet, was penetrated below the sedimentary sequence. A 12-inch casing was cemented in a 17-1/2-inch hole to a depth of 1,090 feet. The hole was re-entered with a 12-inch bit and drilling proceeded to a depth 1,250 feet. Below 1,250 an 8-inch bit was used to drill through several lost circulation zones to a total depth of 1,475 feet. The well was completed open hole below the 12-inch casing point at 1,090 feet. A maximum down hole temperature of 198˚F was recorded at 1,250 feet.

A 72-hour injection test was performed after cleaning out the well using airlift. A constant flow rate of 450 gpm was used throughout the test. At the end of the 72-hour test the water level in WE-3 was 14 feet 11 inches below the surface. This is an increase of 88 feet 1 inch over the static water level of 103 feet. The water level in Well WE-2 was also monitored. The water level increased by 1 foot over the static level of 110 feet, indicating hydraulic communication between the two wells. Flynn, (1985b) reported that based on the injection test the injectivity of Well WE-3 was 8,500 gal/day/ft. He also stated that a recovery test indicated an injectivity value of 8,000 gal/day/ft, which is in good agreement with the injection test value of 8,500 gal/day/ft. Flynn (1985b) went on to state that using an average production rate of 200 gpm the static water level after 20 years of continuous pumping would be 51 feet below the surface.

WELL WE-4

Well WE-4 was drilled in January 1995 to a total depth of 1,625 feet. Lithologies encountered included alluvium, Hunter Creek sandstone, and Kate Peak formation. Eight and one-half -inch casing was cemented to 640 feet and a 6-inch liner was hung from 600 feet to total depth (TD), (Flynn, 1995). The highest temperature, for any well in the Moana Geothermal Area, 234˚F, was measured in Well WE-4 at a depth of 1,000 ft. The well does not produce sufficient fluid or accept fluid in sufficient quantities to be used as a production or injection well. The well is shut in at the present time.

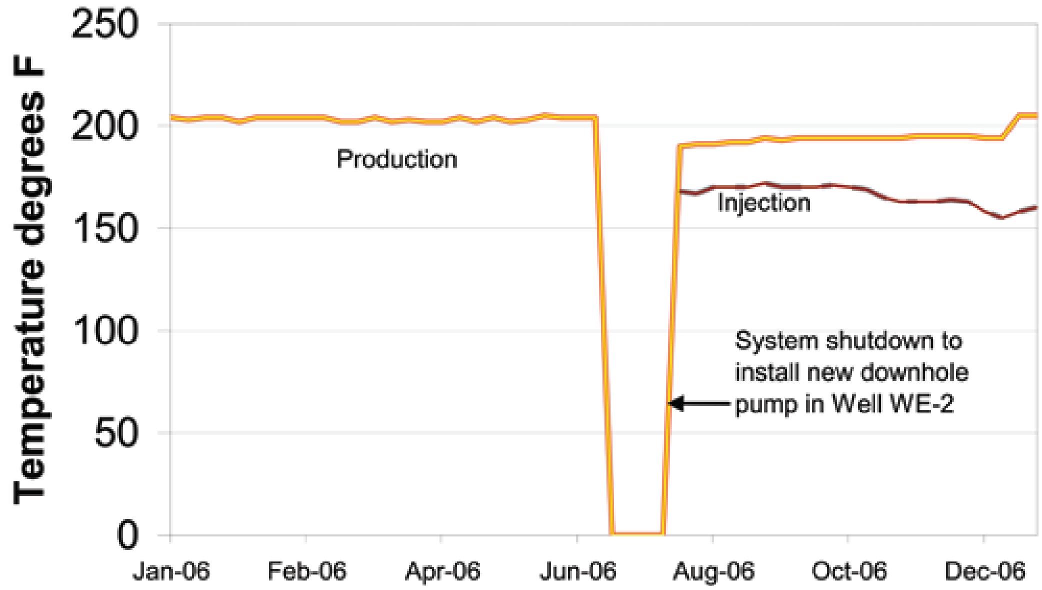

Figure 2. Production and injection temperatures – 2006.

FLOW RATE

Geothermal fluid flows are measured as instantaneous flow reading from a totalizing meter on a weekly basis. Flow rates during the winter months vary from 375 to 400 gallons per minute (gpm). During summer months the flow rate of geothermal fluid is between 200 and 250 gpm. The maximum instantaneous flow rate recorded was 440 gpm during January 2004. Installation of new heat exchangers this July should allow for a decrease in geothermal fluid flow due to increased efficiency.

TEMPERATURE

Temperatures of the geothermal fluids produced in 2006 are presented in Figure 2. During the first half of the year temperatures remained relatively constant between 203 to 205˚F . After the installation of the new 40 hp motor and pump in the production well the temperatures were lower, in the 190 to 195˚F range, until the last two weeks of the year where the temperature jumped up to 205˚F. The lower temperature after installation of the pump may reflect the lack of stress on the reservoir until late in the year when flow rates were 400 gpm and the temperature of the produced fluids climbed to 205˚F. The temperature of the injected fluid ranges between 155 and 172˚F depending on the load.

CHEMISTRY

The geothermal fluids consist of dilute (900 to 1,300 part per million [ppm] TDS) sodium-sulfate waters that are widespread in western Nevada. Silicate (SiO4) concentrations range from 110 to 127 ppm and the pH is slightly basic at 8.3. The geothermal fluid must be separated from potable ground water because of high Fluoride (≈5 ppm) and Arsenic (≈0.13 ppm) concentrations, which exceed drinking water standards. These fluids pose only minor problems with scaling of mineral precipitate.

INJECTION OF GEOTHERMAL FLUIDS

Nevada Geothermal Utility Company operates under an Injection Permit (NEV30013) administered by the Ground Water Protection Branch, Bureau of Water Pollution Control, Nevada Division of Environmental Protection. The permit requires that several parameters be measured and reported. These are 1) flow rate in gpm, 2) water level in feet, and 3) temperature of the produced fluids. A mechanical integrity test is required every five years as a condition of permit renewal. The permit limits injection into Well WE-3 to 300 gpm and 200 gpm into Well WE-1. Therefore the total permitted injection of geothermal fluid is 500 gpm.

SPACE HEATING DISTRICT

The pipes for distribution of the geothermally heated water to the individual lots were installed when all other utilities were buried. Distribution lines vary from 6-inch to 2-inch diameter. The hot water distribution piping is stubbed into 36 x 24 inch utility boxes on each lot. The Warren Estates subdivision has 60 lots and was built in 1983. Ameron fiberglass pipe was used for both the distribution and return lines. Two-inch gate valves in the utility boxes allow for customer hook-up. Balancing valves at the end of lines are used to facilitate return flows. The heated city water makes a circuit through buried pipes in the streets to the lots on the system and returns to the heat exchanger to be reheated.

Manzanita Estates subdivision consists of 102 lots and was constructed similar to Warren Estates except the distribution and return system utilize steel pipe. Corrosion of the steel pipe is the predominant cause of leaks in the Manzanita subdivision, while settlement and breakage of the fiberglass pipe is the major cause of leaks in the Warren Estates.

Initially, each home on the system was equipped with a Btu meter that measured the flow rate and the temperature drop, and computes heat energy consumption in therms (100,000 British thermal units-Btus). There were significant problems, malfunctions and failures with the Btu meters due to their placement in the subsurface utility boxes. For more than ten years, NGUC tried a variety of Btu meters with the same disappointing results.

The major problem with the meters was water saturation of the meter box by lawn irrigation runoff, failure of flow meters, and general failure of the electronics from steam condensation. The Btu meters had only an 8- to 10- month service life. Replacement rates and maintenance costs were very high (Flynn, 2000).

NGUC, with assistance from their consultant Thomas Flynn, performed a study of the efficiency and reliability of the Btu meters (Flynn, 2000). Based on this study and evidence of meter failure the Public Utility Commission of Nevada (PUC) issued a Compliance Order in June of 1998 allowing Nevada Geothermal Utility to implement a flat-rate billing program for customers at Warren/Manzanita Estates. The price per square foot was based on calculations using three estimates of energy consumption: 1) natural gas utilization, 2) an estimate of natural gas use by the local utility company, and 3) an estimate by the USDOE based on degree days. A valid measure of the square footage of homes within the system is maintained by the Washoe County Assessor's Office. The proposed flat schedule for 1998 is presented in Table 1.

Table 1. Proposed 1998 Flat Rate Billing (from Flynn, 2000).

ITEM	RATE
Monthly service charge	$3.25per household
Space and domestic water heating	$0.16 per sq ft (75% of natural gas)
Swimming pool	$30.00 per month
Spa/jacuzzi	$10.00 per month
Driveway deicing	$50.00 per month

The current billing rates are presented in Table 2. The rate for space heating is still based on 75% of the price for natural gas and has increased 29% in the past year.

The rate for swimming pools is based on 4 months (June-September) usage and amortized over 12 months. So the cost to heat a pool for four months is $527.28 a year. Driveway deicing is calculated for a six-month period and is also amortized over 12 months. Therefore the cost for deicing a driveway is $282.48 per year.

Table 2. Current billing rate.

ITEM	RATE
Monthly Service Charge	$3.25 per household
Space & domestic water heating	$0.38 per sq. ft. (75% of natural gas)
Swimming pool	$43.94 per month
Spa/Jacuzzi	$18.84 per month
Driveway de-icing	$23.54 per month

Rates can only be raised by NGUC in January following an increase in the cost of natural gas by Sierra Pacific Power Company. Therefore, there is a lag time of as much as six months before NGUC customers see an increase in rates. In January 2008 major modifications to the Service Agreement are anticipated. These will include an increase in the monthly service charge to $6.50 per month, comparable to SPPCo's increase in May 2006 and assessing an additional charge for those customers with outdoor pools that wish to keep them heated year round. This will also require the use of an insulated pool cover. Customers with indoor pools will be assessed a lower rate than outdoor pools. In addition, the 75% of the price of natural gas for space and water heating may increase to 85% of the price of natural gas. With the inefficiencies of heat conversion from the combustion of natural gas, the actual cost will be about 75% of the cost of equivalent thermal energy.

SYSTEM OPERATION

Geothermal fluid at a temperature near 200˚F (190-205˚F) is pumped from production well WE-2. The 40 hp turbine pump supplies the pressure to force the geothermal fluid through the flat-plate heat exchangers and down the injection well, Figure 3. Heat from the geothermal fluid is transferred to municipal water across the heat exchanger.

The heated municipal water having a temperature between 140 - 165˚F is distributed to each lot in the subdivisions. The water is delivered at a pressure above 10 psi. During winter, the return flow temperature can be as low as 110˚F.

A homeowner wishing to be connected to the system must comply with the following:

- ✓ All homes must have back up heating and domestic hot water systems.
- ✓ All homes must have shut-off valves outside the utility box on both the supply side and return side. A floor drain must be installed in the mechanical room.
- ✓ All home systems must be equipped with a circulating pump. The customers' system should not rely on the

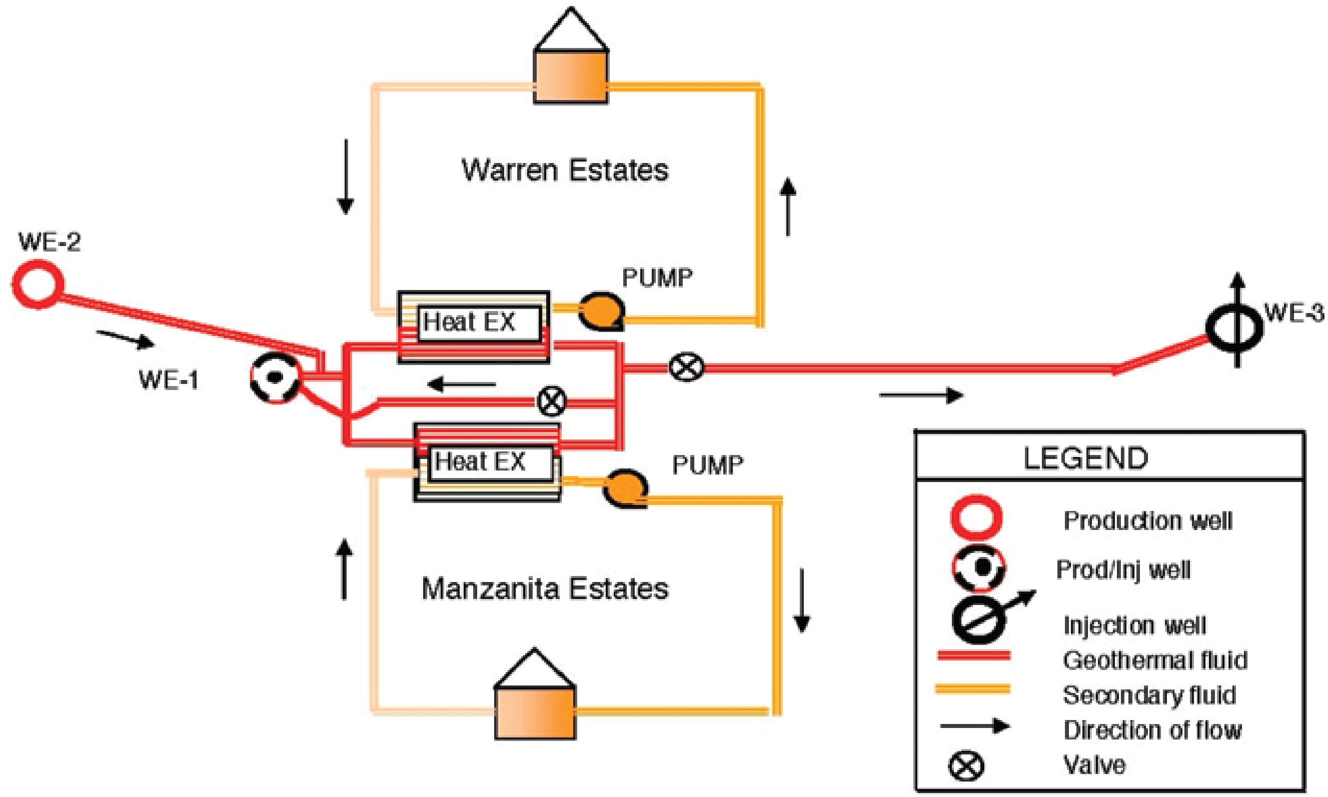

Figure 3. Schematic diagram of Nevada Geothermal Utility Company space heating district.

differential pressure between the hot and cold side to move the water through the home system.

✓ All zone control valves, pressure relief valves and other components of the system must be rated for 100 psi. The pressure relief valves should be set at 100 psi.

✓ All systems must be equipped with a drain valve in the utility room.

✓ The size of the pipe from the utility box to the home should be no larger than 1- ½ inch diameter.

✓ Pipe insulation is offset from the house to the utility box and all pipes within the dwelling should be insulated to R-11 or better. The insulation should be waterproof and non-collapsible or non-compressible.

✓ All systems must be equipped with an automatic pressure shut-off valve.

✓ Homes should utilize forced air heating systems rather than hot water baseboard systems.

Nevada Geothermal Utility Company customers realize a significant savings in heating costs when compared with homes heated by natural gas. Homes in the Warren and Manzanita Estates range in size from 2,176 to 7,080 square feet, with the average home being 3,728 square feet. Table 3 compares 3 homes heated with natural gas to the same home heated with geothermal energy. Annual savings range from $197.42 for a 3,176 square foot home to $483.52 for a larger 5,306 square foot home. The percent savings is between 17.1 and 22.2 percent per year.

Table 3. Comparison of Annual Geothermal Space Heating Costs to Natural Gas Heating Costs.

Square Feet	Natural Gas Cost	Geothermal Cost	Annual Savings	Percent Savings
3,176	$1,157.46	$ 960.04	$197.42	17.1
3,697	$1,422.39	$1,170.99	$251.40	17.7
5,306	$2,177.55	$1,694.03	$483.52	22.2

CONCLUSIONS

Geothermal energy is an effective, clean, and efficient method of supplying heat to residences in Warren and Manzanita Estates. It is renewable and non-polluting. However, it is not free and appropriate fees must be established to satisfy both the owner of the utility and the consumer.

The owner is responsible for operation, regulatory permitting, accounting and maintenance. The customer must install specialized heat exchange equipment in order to utilize the geothermal heat available to his/her lot. The financial burden is borne by the owner and the consumer and the environmental benefits are shared equally.

Expansion of the Geothermal Utility Company system will depend upon the efficiency gained by replacing the original heat exchangers with new ones. These improvements coupled with the addition of variable frequency drives to the geothermal production well motors may allow for the addition of several more homes to the system.

Maintenance of the aging system is problematic and it is hoped that it will continue to provide space and hot water heating for the foreseeable future.

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