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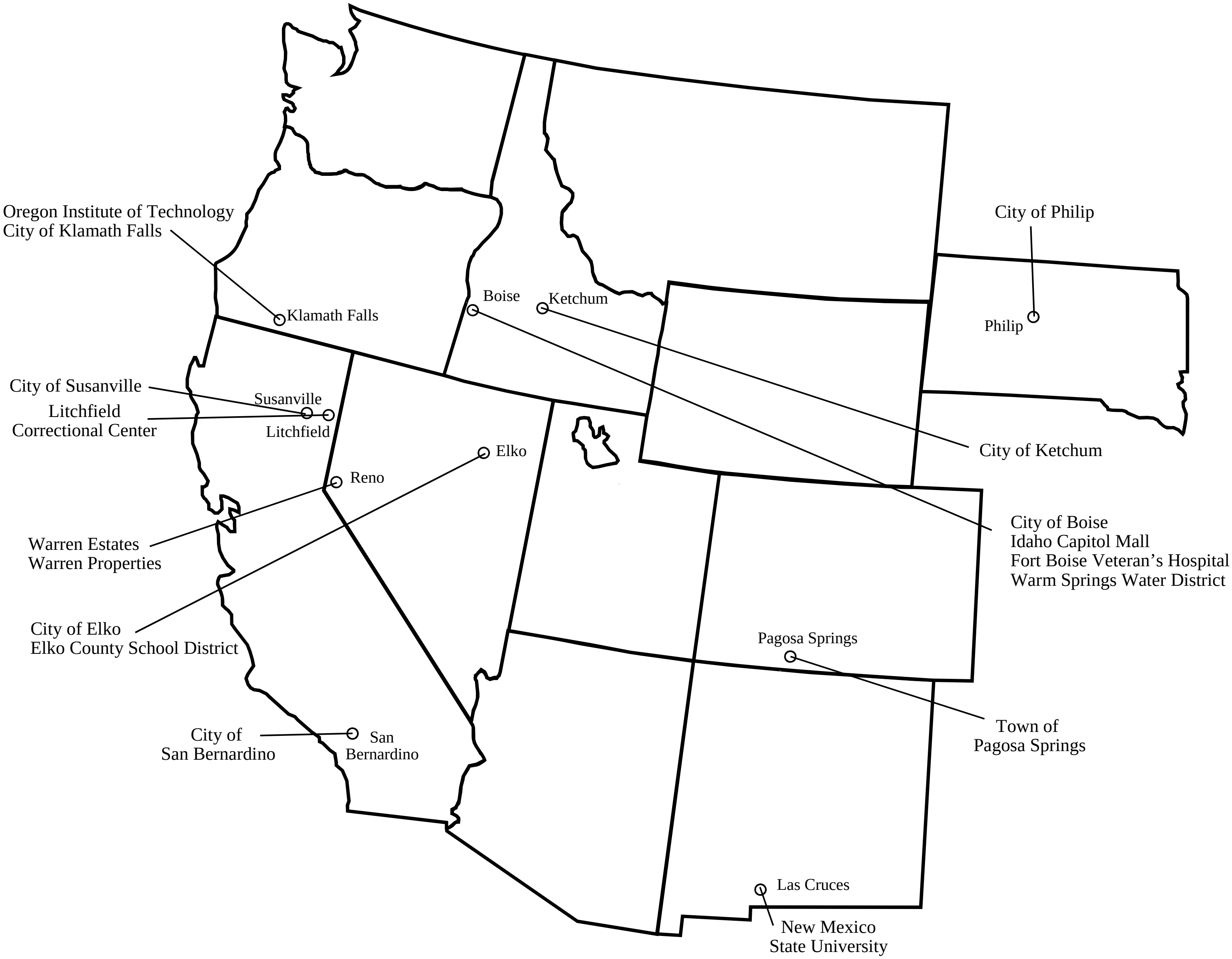
PHONE NO. (541) 885-1750



GEOTHERMAL DISTRICT HEATING

Vol. 18, No. 3 August 1997

GEO-HEAT CENTER QUARTERLY BULLETIN

ISSN 0276-1084
A Quarterly Progress and Development Report on the Direct Utilization of Geothermal Resources

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Cover: Location map of geothermal district heating systems in the U.S.

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Oregon Institute of Technology
3201 Campus Drive
Klamath Falls, OR 97601
Phone: 541-885-1750
Email: geoheat@oit.edu

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EDITOR

John W. Lund
Typesetting/Layout – Donna Gibson
Graphics – Tonya "Toni" Boyd

WEBSITE **http://www.oit.edu/~geoheat**

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ELKO, NEVADA, DISTRICT HEATING SYSTEM

Mike Lattin
General Manager
Elko Heat Company

INTRODUCTION

Elko Heat Company has been operating a geothermal district heating system in Elko, Nevada, since December 1982. This system is a direct-use application and serves 17 customers, and conveys approximately 80 million gallons of 178°F geothermal water annually (Table 1). The customers are primarily using the geothermal water for space heating and domestic hot water heating. Two customers are utilizing their return water for winter-time snow and ice melting on walkways, and one is utilizing a heat pump system. The customers are using the geothermal water to heat a controlled loop system via plate-type heat exchangers. Another customer, a commercial laundry, is softening geothermal water, and using it directly for wash and rinse water.

The Elko Heat Company project was funded by the Department of Energy in the late-1970s. The project was to demonstrate the technical and economical feasibility of utilizing low-to-moderate temperature (less than 250°F) geothermal energy in direct-use applications. The project received 100 percent funding to conduct resource exploration; drill, develop and test the geothermal resource; and install the distribution and disposal systems. Each of the customers were responsible for the design and construction of its system retrofit to geothermal heat. The Department of Energy provided an $827,000.00 grant to Elko Heat Company to complete the system. The Elko Heat Company project was one of 23 projects funded by the Department of Energy under a Program Opportunity Notice (PON) solicitation, 15 of which became operational.

Table 1. Comparative Analysis - Elko Heat Co. Geothermal Well No. 1 - Avg. Elko City Water and Nevada State Drinking Water Standards

Parameter	Elko Heat Co. Geothermal Production Well No. 1*	City of Elko**	State of Nevada Drinking Water Standards***
TDS	605	416	1000
Hardness	214	190	No Limit Set
Calcium	61	56	No Limit Set
Magnesium	12	12	125
Sodium	117	44	No Limit Set
Potassium	47	13	No Limit Set
Sulfate	77	51	500
Chloride	17	33	400
Nitrate (NO_3)	No Test Data	3	45
Alkalinity	405	145	No Limit Set
Bicarbonate	378	176	No Limit Set
Carbonate	<1	0	No Limit Set
Fluoride	1.9	.25	1.6 - 2.0
Arsenic	.01	.002	.05
Iron	.26	.13	.60
Manganese	No Test Data	.008	.050
pH	6.6	7.74	No Limit Set

* Test samples from artesian flow test Aug. 1981
** Average values from Table VI, Elko Water System Analysis, Chilton Engineering 1980
*** Water Supply Regulations, Part 1, State of Nevada, Oct. 19, 1997

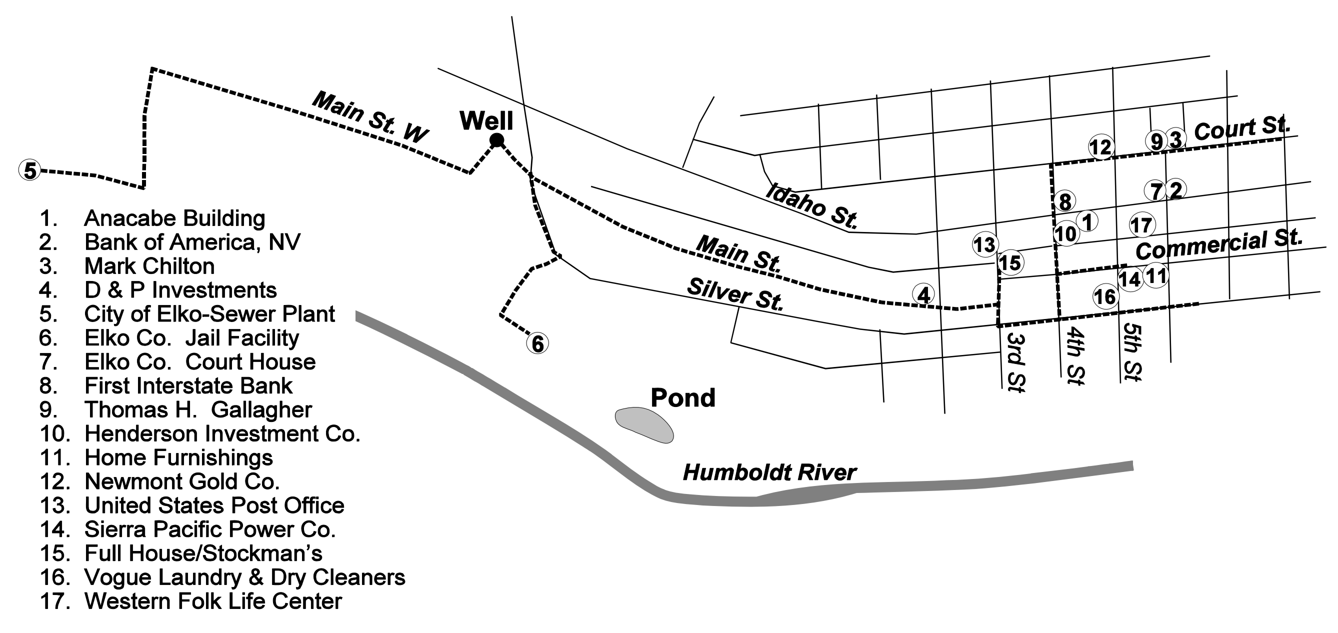

Figure 1. Elko District Heating System.

BACKGROUND

Recognizing the undeveloped potential of the geothermal resource in the Elko area, Elko Heat Company was formed in 1979. The purpose of the company was to develop and utilize the geothermal resource in Elko. Prior to this project, geothermal energy was utilized on a very limited basis in the area. The system was designed by Chilton Engineering of Reno, and then maintained and operated by Elko Heat Company. The initial customer base of three was not large enough to warrant the investment; but, recognizing the potential to expand, the Elko Heat Company was willing to subsidize the system. This approach paid off, as 17 customers are on the system today (Figure 1).

THE SYSTEM

Elko Heat Company has one geothermal production well drilled to a depth of 865 ft. The well is cased with 12-, 8- and 6-inch carbon steel casing. The production zone of the well is the last 65 ft and is not cased (open-hole completion). The well flows approximately 425 gpm under artesian conditions at 178°F. The shut-in pressure of the well is 52 psi. The flow, pressure and temperature have remained unchanged during the 15 years of operation. The well is equipped with a 15-hp lineshaft turbine pump. The pump is used during periods of high flows to boost the system pressure. The wellhead discharge piping is constructed out of Schedule 40 carbon steel pipe (Figures 2 and 3). In 1995, a buried 10-inch elbow failed due to external corrosion and had to be replaced.

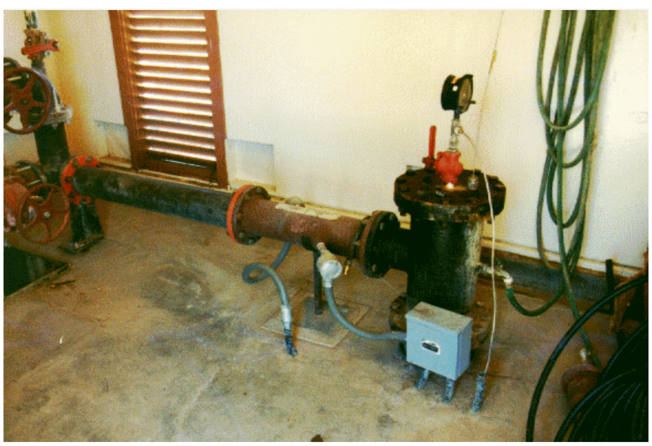

Figure 2. Main production line showing ultra-sonic flow meter.

The piping system consists of a two-pipe system, an insulated supply pipe and an uninsulated return pipe (Figure 4). The majority of the system piping is 8-inch diameter, with some 6-inch and 4-inch diameter pipe. Services to the individual customers are normally 2 inch, and in a few instances are 3 inch and 4 inch for the larger customers. Services were initially constructed out of carbon steel and lasted two to four years before failing due to a combination of internal and external corrosion. Service connection failures occurred at pipe joints, screwed fittings being the first to fail and then Victaulic (grooved-end) followed by welded. It was felt that the stress on the joint area caused by threading, grooving and welding made it susceptible to corrosion.

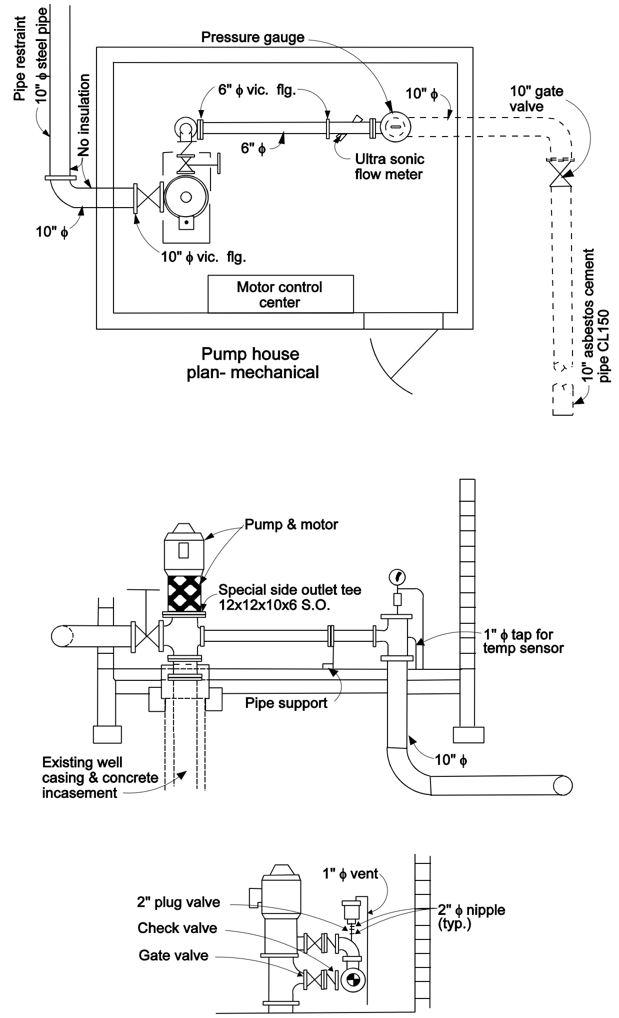

Figure 3. Wellhead equipment and piping.

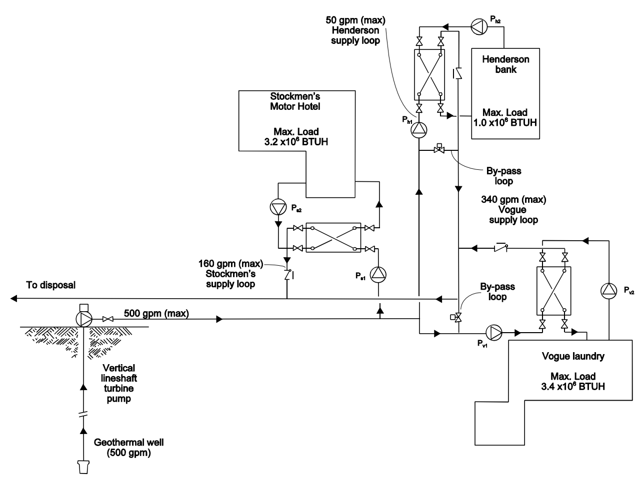

Figure 4. Open-loop distribution system schematic.

Small diameter service piping 4 inches or less was replaced with Type 304L stainless steel, with welded or flanged joints. Stainless steel piping was quite expensive and thus, was then only used on the supply line. High Density Polyethylene (HDPE) pipe was used for the return line piping since it was determined that the HDPE pipe was suitable for use in the relatively low pressure and temperatures encountered in the return piping. HDPE piping is a plastic pipe with thermally fused joints and is relatively inexpensive. This type of pipe is not susceptible to internal and external corrosion; but, its use is limited to temperatures less than 140^{o}F and 50 psi (lower pressures will allow higher temperatures). Valves used on services were stainless steel butterfly valves with gear-type operators and 2-inch operating nuts for buried valves. Each customer's service has a shut-off valve on the supply and return line in close proximity to the customer's building. The customer's geothermal service is charged by the 1000s gallons of supply water. Elko Heat Company initially started charging $1.25/1000 gallons and in 1992, increased the rates to $1.38/1000 gallons. It is estimated that this rate for geothermal energy equates to approximately 30 percent of the equivalent rate for natural gas. Flow meters are installed inside the customer's facility and read monthly by Elko Heat Company.

It was found that the resulting 70 percent savings over conventional fuel was not enough to justify customer's investment in system retrofit to geothermal. Elko Heat Company developed the following incentives to make it worthwhile for the customer to retrofit: charging 50 percent of the normal rate for the first three years of the contract, free geothermal use for two years and/or Elko Heat Company paying for the retrofit and the customers pay the rate they were paying for conventional fuel to Elko Heat Company for the next five years. Each of the customer requirements were unique and required special consideration. An existing hydronic system was a relatively easy and inexpensive retrofit; where as, gas-fired air handlers required more complexity and expense. A new building could be designed to utilized geothermal energy at a relatively small additional cost.

In order for geothermal energy to be cost effective, a potential customer has to be in relatively close proximity to the distribution system and be a relatively large energy customer. Individual residences were too small to be cost effective; but, commercial and office complexes exceeding 10,000 sq ft were good candidates for retrofitting.

The main distribution system was installed in city streets along with other utilities, water, sewer, natural gas, telephone, television and electrical. Conflicts with other utilities have not presented nor caused any serious problems. The main problem encountered involves working in streets with traffic and the expense of replacing pavement.

The distribution piping is asbestos-cement (transite) pipe and conveys geothermal energy to each customer. The supply piping is epoxy-lined and coated with polyurethane insulation with an asbestos-cement pipe outer jacket with rubber end seals over the insulation to prevent moisture entry. Jointing of the asbestos-cement pipe is by bell-and-spigot joints, using EPDM gaskets to withstand the higher temperatures. Manufacturing of this type of pipe (asbestos-cement) was discontinued approximately 10 years ago; so, it is no longer readily available.

The return piping is asbestos-cement with bell-and-spigot joints and EPDM gaskets. At the time, asbestos-cement was considered by the company to be the most cost effective piping material due to materials and installation cost. No problem with corrosion has occurred with the asbestos-cement pipe. If it became necessary to expand the system today, we are unsure of the type of piping material we would select. Alternatives would include: steel (both carbon and stainless), ductile iron, and fiberglass.

Valves and fittings were normal water-work type fittings compatible with the asbestos-cement pipe. These were of the flanged or mechanical-joint type connections, using high-temperature gaskets. Initially, problems were encountered with the flanged fitting; in that no matter how tight the bolts and nuts were tightened, once hot water was circulated through the pipe, the bolts elongated enough that they became loose and had to be re-tightened until the temperature was maximized.

These fittings lasted approximately 15 years in service and failed primarily due to external corrosion, resulting from a combination of soil types, ground moisture, and temperature of the fitting. It was felt that due to the relative low cost of these fittings and ease of installation, that these were the most cost effective, even though they had to be replaced after 15 years of use. The new valves and fittings are being installed with 12# magnesium anodes, in an effort to extend the life expectancy. These valves and fittings are constructed of ductile iron, which exhibited good resistance to internal corrosion, but are susceptible to external corrosion. Hopefully, the anodes will extend the useful life.

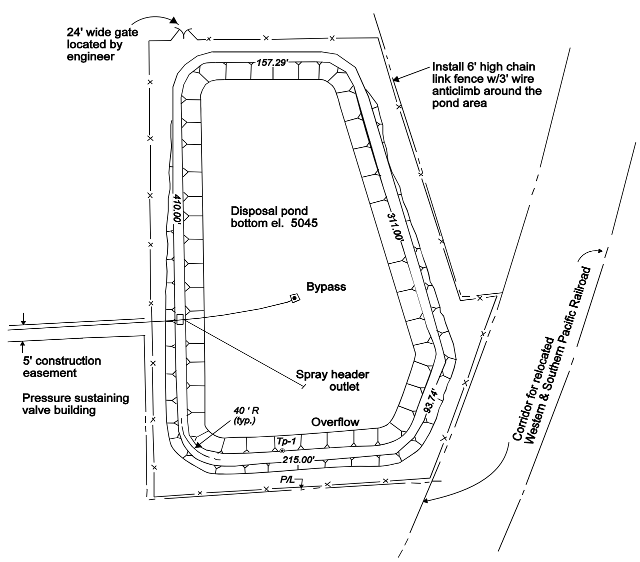

Figure 5. Disposal pond.

Elko Heat Company disposal system consists of a 1-½-acre cooling pond followed by discharge on to a wetlands area adjacent to the Humboldt River (see Figure 5). Fortunately, the geothermal fluids are of a good quality and the only treatment requirement is cooling. Occasionally, fog from the cooling pond creates a visibility problem in the area. The same situation occurs at the natural spring sources located in the area.

RECENT MAINTENANCE AND REPAIRS

The existing maintenance problems that are currently being experienced are:

1. External corrosion to ductile iron valves, fittings and steel bolt up hardware,

2. AC piping breaking due to load stresses and deterioration, and

3. Probably external and internal corrosion of wellhead equipment.

Recent repairs include:

1. Replacing a 10-in flange coupling adapter at the production well main line with all stainless steel fittings. The original flange coupling adapter was installed during emergency repairs and, this, was only a temporary solution. The repairs included placing a stainless steel flex coupling along with the flange coupling adapter to provide a connection to the AC main line. A 6-in wide protection wrap was then applied to the stainless steel fittings. This was installed to insure that if future work is required on the fittings, the stainless steel bolts will be protected.

2. Emergency valve replacement at the intersection of 4th and Idaho Streets. The 6-in supply valve was leaking to the surface at this point, and when exposed by excavation, it was externally corroded. New 6-in M.J. Resilient Wedge Gate Valves and 6-in stainless steel flex couples were then installed to replace the old valves. All the fittings were again wrapped and a 17-pound sacrificial anode was installed to protect the ductile iron valves. They were then backfilled with pea gravel and provided with an access riser inside a 6-in PVC pipe.

3. Service valve replacement for the county jail. The valves access box was covered over during a road re-alignment project. When it was uncovered, the valves were inoperable. The shaft seals of both the supply and return valves were leaking. New stainless steel gear-operated butterfly valves with flex couples were then installed. They were wrapped and a PVC pipe was used to protect the valve riser.

CONCLUSION

The Elko Heat Company system has operated successfully for 15 years. There have been few interruptions to the customer's service and no major system failures have occurred to date (this is especially significant, considering there is no backup source of supply). In approximate numbers, the system generates $110,000 in revenue, with system operational cost approximately $45,000 per year (management, maintenance, legal and accounting, and permits for licenses). The peak heat use is 6.4 million Btu/hr based on a 30°F temperature drop. If the Department of Energy grant funding, combined with tax and alternative energy credits that we have available to the customer in the early 1980s was not in place at the time, this project would not have been completed. Fortunately for Elko Heat Company, this was not the case, and Elko Heat Company was successful in locating a suitable resource and overcoming technical and other issues to complete the project.

TOWN OF PAGOSA SPRINGS GEOTHERMAL HEATING SYSTEM

Mark B. Garcia
Geothermal Heating System Administrator
Town of Pagosa Springs

INTRODUCTION

The Town of Pagosa Springs has owned and operated a geothermal heating system since December 1982 to provide geothermal heating during the fall, winter and spring to customers in this small mountain town. Pagosa Springs is located in Archuleta County, Colorado in the southwestern corner of the State. The Town, nestled in majestic mountains, including the Continental Divide to the north and east, has an elevation of 7,150 feet. The use of geothermal water in the immediate area, however, dates back to the 1800's, with use by Ute Bands and the Navajo Nation and later by the U.S. Calvalry in the 1880's (Lieutenant McCauley, 1878). The Pagosa area geothermal water has been reported to have healing and therapeutic qualities.

The Town's geothermal heating system was funded by the Department of Energy (DOE) with additional funds provided by Archuleta County and the Town. The technical consultant during the establishment of the system was Coury and Associates, Inc., with additional contracted support from Hydro-Triad, Ltd. and Chaffee Geothermal, Ltd. The total cost to complete the system was over 1.4 million dollars. Ownership of the system was transferred to the Town following the termination of a three year pay-back contract with DOE (Rafferty, 1989). Currently, the system has 15 customers (2 residential, 13 commercial)(Figure 1) with an average annual operating budget of $40,000. The system is fully operational, with several additional projects underway.

GEOTHERMAL SYSTEM SPECIFICATIONS

The geothermal source for the system is one of two production wells drilled during the initial phase of the geothermal project. The wells (PS-3 and PS-5) are 300 and 274 feet deep, provide geothermal water at 131°F and 149°F, have artesian flow rates of 600 gpm and 800 gpm, respectively (Rafferty, 1989). At present, PS-3 is capped but can serve as a back up to Well PS-5. The PS-5 well head is secured with two new 10-inch stainless steel gate valves. Removal of the original 10-inch iron gate valves, required due to excessive corrosion, was completed by a drilling crew during the spring of 1996.

Geothermal water is piped approximately 300 feet from the well head to the system utility building, which houses heating equipment and machinery. A Y-strainer and air/gas relief valve make up the additional fittings along the route to the utility building. Fiberglass piping (10-inch) is used above the gate valves and on all geothermal water transported to and from the utility building.

Geothermal water enters the system utility building at 146°F and passes through a plate heat exchanger (Figure 2) transferring heat to a fresh-water loop used to deliver heated water to all customers. A flow control valve is located upstream of the heat exchanger and allows manual flow control of the incoming geothermal water. The heat exchanger has a flow rate capacity of 1,000 gpm and a heat transfer area of 2,650.5 ft^2. The exiting geothermal water temperature

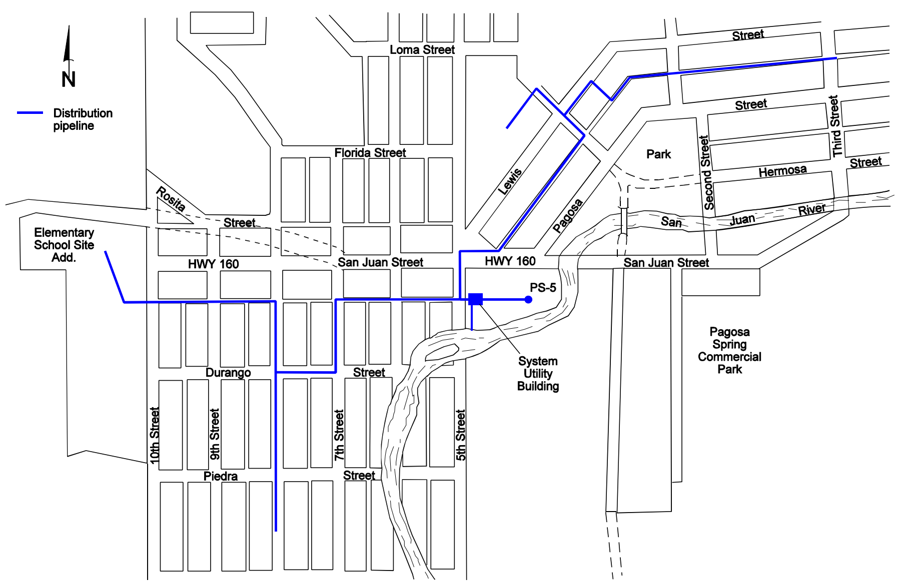

Figure 1. Distribution system layout.

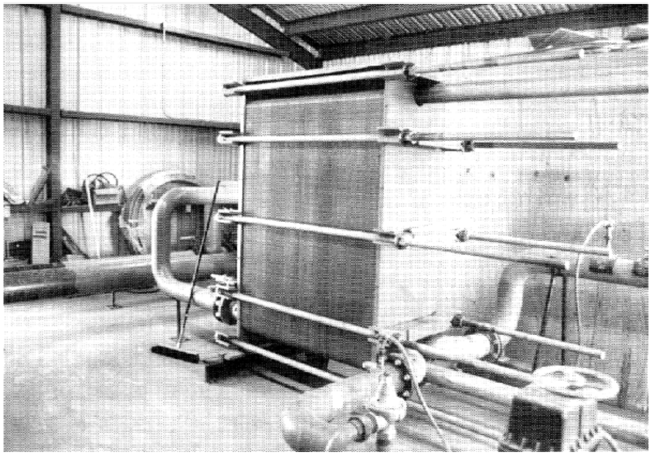

Figure 2. Plate heat exchanger.

varies between 120-130°F, depending on the heating load and the corresponding return water temperature of the fresh-water loop. A flow control valve is located downstream of the heat exchanger and allows manual flow control of exiting geothermal water. The exiting geothermal water flows approximately 200 feet, then through a fiberglass weir which measures water usage and monitors water flow rates and is finally discharged into the San Juan River. Monitoring of discharge geothermal water is also conducted at this site by the Colorado Division of Water Resources.

The fresh-water, closed loop distribution network consists of two independent closed loops supplying hot, fresh water to customers. The supply water temperature is between 135-141°F and varies with different flow rates and heat exchanger characteristics. The return water temperature is between 120-130°F, depending on the heating load. The return water is pulled through the system with two horizontal centrifugal (25 horsepower) pumps piped in parallel. The distribution network flow rate is controlled with manual flow control valves located between the circulation pumps and the heat exchanger. Only one circulation pump is required to circulate the current supply of heated water to all customers.

The system operating pressure, approximately 60 psi, is controlled with a flow regulator situated on the ¾ inch make-up water supply line that is piped into the return loop. In addition, a 2 inch make-up supply water line is also piped into the return loop and controlled with a 2 inch gate valve. The larger make-up water line is normally closed and used only following repairs or during the system charging which is completed prior to start-ups. Figure 3 identifies the piping schematic for the geothermal and fresh-water distribution network.

The fresh-water distribution piping located within the utility building is Schedule 40 steel, seamless pipe and is in 6 and 10 inch sizes. The fresh-water distribution piping buried on both loops is epoxy lined, Asbestos Cement (AC) pipe manufactured by Johns-Manville with pipe sizes in 6, 8 and 10 inches (ID). All fresh-water supply piping has polyurethane insulation with an AC jacket. No insulation is provided on fresh-water return piping.

GEOTHERMAL SYSTEM OPERATIONS

As mentioned above, all controls are manually operated and monitored daily. Operation logs are used to record all temperatures, flow rates, operating pressures and water losses. The original project design included an automated control system with automated flow control valves, the necessary remote sensing ports and a computer to monitor and control the entire project. The automation was not completed due to cost overruns. All the automated valves and sensing ports were installed, however.

Under present operating procedures, the full flow of artesian geothermal water travels from Well PS-5 to the utility building. A manual flow control valve, however, regulates the inlet geothermal water flow rate through the heat exchanger to keep the affect on the aquifer at no greater than the flow rate of the Town's geothermal water rights. The inlet flow rate through the heat exchanger is determined by the required heat load which varies between fall and winter periods. A minimal flow rate is maintained in an effort to conserve the geothermal resource. During normal winter months (December-

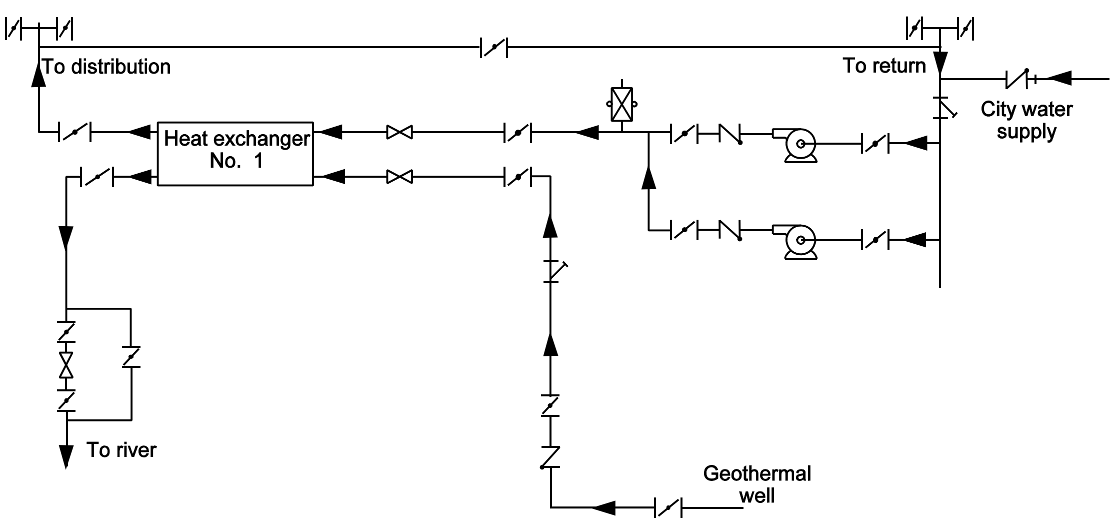

Figure 3. Central mechanical room piping diagram.

February), a maximum flow rate (450 gpm) is typically required in order to provide adequate heating to all customers during peak periods. No back-pressure is placed on the heat exchanger by the throttling of the downstream flow control valve and exiting geothermal water is not restricted.

The fresh-water return flow rate is closely matched to the geothermal water inlet flow rate in order to achieve optimum efficiency. This flow rate is manually controlled with flow control valves located between the circulation pumps and the heat exchanger and monitored with a flow meter. The heat exchanger efficiency varies due to the manual control of the system and the changing heating needs dictated by climate and weather patterns.

The operating pressure of the fresh-water distribution loops is set at 60 psi using a pressure regulator located in the make-up water supply line. The make-up water is provided by the local water district and piped into the return loop, as mentioned above. The average water loss for 15,000 linear feet of pipe is approximately 2,600-3,200 gallons per day or 1.8-2.2 gpm. Adjustments to the system are made when the heat load changes due to weather conditions or if minor adjustments are necessary for balancing loops or accounting for increased water loss.

Customers receive heated water from the distribution loop, circulate the water through various heating units (i.e., baseboard radiators, air distribution units, hydronic heating systems) and return the cooled water to the return loop. Larger customers have by-pass modulating valves that re-circulate water through their various heating units if the water is still hot enough to distribute heat before returning to the return loop. Customer heating systems also operate at 60 psi.

The Town monitors flow rates and the amount of heat (Btu's) used by customers by using a flow meter and temperature sensing probes in conjunction with a Btu meter. The Btu meter consists of two readouts (Btu's and gallons) and a printed circuit board situated within a J-box. The Btu meter tabulates pulses from the flow meter and monitors supply and return temperatures while calculating the correct Btu and flow rate consumption and ultimately displaying the values on the corresponding meters. A few smaller customers do not have Btu meters and are billed based on the average temperature drop of the water used and monitored with a flow meter.

When a new customer comes on line, the Town completes the service tap and includes the supply and return isolation valves, temperature sensing probes and Btu and flow meters. All other piping, circulation pumps and assorted piping fixtures are furnished and installed by the customer. In addition, each customer is also responsible for maintenance of his own system.

The two independent loops have different load requirements and can be manually controlled to balance the different needs. The east loop services the downtown area and requires the majority of the district heating capacity. Customers include the Junior and Senior High Schools, two churches with accessory buildings, two large office buildings, five retail buildings, Town Hall and two residences. The west loop has fewer customers and, consequently, a smaller heating requirement. Customers on the west loop are the Elementary School, a bank, and the Archuleta County government building with a new addition which includes offices, conference rooms and the jail. The public library is also on this loop but presently does not use the geothermal heating system. The retrofitting of the library to receive geothermal heat was inadequately designed.

In addition, two commercial customers, a church and the schools use the heated fresh return water for melting snow on sidewalks adjoining their buildings. To melt snow, hydronic heating systems use a small heat exchanger to transfer heat from the fresh return water to a glycol fluid which is distributed through tubing situated within sidewalks using small circulating pumps. The sidewalks are maintained at approximately 50°F using the hydronic system without any snow or ice accumulation. The snow melt design works extremely well and is well accepted by the customers.

GEOTHERMAL SYSTEM MAINTENANCE

General maintenance on the geothermal system includes repair of failed pipe, cleaning of all strainers in various locations, operation and lubrication of all valves, repair of faulty Btu meters, repair or replacement of various pipe fittings (i.e., check valves, gate valves, temperature and pressure gauges) and overhaul of the heat exchanger and pumps, when necessary. Additional maintenance is required both on other wells and a geothermal fountain owned by the town and on the utility building and the other outbuildings and fences appurtenant to the geothermal system. Larger maintenance projects are completed during the summer months and have included the plugging of older geothermal wells (Brown Well and previously plugged County Well) and the reworking/casing of existing wells (PS-5 and Rumbaugh).

Repairs are made on water leaks as they are discovered and often require the shut-down of the plant during these repairs. A leak detection company hired to find leaks throughout the entire fresh-water distribution system, did not find any leaks. The current minimal water loss is likely a result of several small leaks which are impossible to detect with leak detection equipment.

A large part of the system's budget is for maintenance, repair, spare parts and emergency contingencies. Maintenance has become a top priority for the system.

A near-term (1-2 years) goal for the geothermal system is to develop the necessary code and procure the necessary equipment needed to automate the geothermal distribution facility. Automation will allow the facility to run more efficiently, reduce costs and further preserve the geothermal resource. Some consultant services may be required in order to complete the project correctly and in a timely manner. In addition, maintenance procedures will need to be developed and training may be required in order to familiarize personnel with the new equipment.

GEOTHERMAL SYSTEM ADMINISTRATION

The system employs one administrator part-time in order to manage all system operations. The administrator's duties include daily system monitoring, monthly meter reading and billing, completing schedule maintenance, coordinating and completing emergency repairs, providing geothermal line locates to utility companies and contractors, troubleshooting customer problems, coordinating new customer installations, coordinating tours and assisting in accommodating all public inquires concerning the geothermal system.

At present, the system budget is approximately $40,000/year, while only approximately $22,000 is generated in revenue. The deficit, funded by the Town, was caused primarily by expenditures for much needed maintenance and other capital improvements. It is expected that the budget deficit issue will be resolved when new customers, included in the customer list above, come on-line for the 1997/98 heating season and when the large maintenance projects are completed.

Customer meter reading and billing are completed monthly. A standard spreadsheet software program is used for the billing. The current rate charged for geothermal heating is $0.45 per Therm ($10^5$ Btu). The current geothermal heating rate is 25% less than the local natural gas rate (in Therms) and 30% less than the local electricity rate (in Kwhr). System monthly revenues vary due to weather conditions and range from $2,100 in October, to $6,300 in January.

The Town provides assistance, including equipment and manpower, to the system administrator from other departments. These departments include the Street and Maintenance Department, Parks and Recreation Department, the Town Administrator and the Town Clerk.

GEOTHERMAL SYSTEM ISSUES

The geothermal system has operated successfully and is well accepted by customers and the public. With new customers coming on-line, the system heating output is approaching peak capacity based on the Town's current adjudicated geothermal water rights for Wells PS-3 and PS-5 of 450 gpm (1 cfs). The original geothermal system was designed for twice the current capacity (1,000 gpm) and included an additional plate heated exchanger and two circulation pumps. The project was downsized during construction and following the drilling and testing of the new production wells, due to increased project expenses.

During the initial phase of the project, test wells were to be drilled in an attempt to determine the hydrogeological and geothermal characteristics of the aquifer (Galloway, 1980). The test wells were not completed as intended because numerous problems were encountered during their drilling. A small fault was encountered during the drilling of a large test well which affected all local geothermal wells and the surface hot spring. The event caused concern over the potential impact of an operating geothermal system on other geothermal wells. When the fault was repaired (cased) and the drilling completed, however, all the monitored wells returned to their previous flow rates and pressures. The DOE aquifer study was, therefore, inconclusive, but much was learned concerning the general nature of the geothermal aquifer and its circulation system (Galloway, 1980).

There is still concern regarding the use of the geothermal resource and the impact of established uses on the aquifer. The Town has applied to the Water Court to allow a transfer of geothermal water rights from the Town's Rumbaugh Well to Wells PS-3 and PS-5 to allow the geothermal system to operate at design capacity and to allow the Town to extend service to additional customers. This transfer case has been pending for several years. Numerous attempts have been made to resolve all disputes without a court trial. The objecting parties are primarily users of geothermal water for recreational (bathing) activities. Since the geothermal system discharges water at 120ºF, a level of heat sufficient to accommodate the geothermal water use of the objectors, the Town proposed the establishment of a pipeline company to distribute the Town's geothermal discharge to affected parties. The pipeline company could supply the affected parties with water in excess of their current water rights and eliminate the need for the use of their wells, further reducing the impact on the aquifer. Following the recreational use and depletion of the available heat of the Town's discharge water, geothermal water could be discharged into the San Juan River. Negotiations are currently underway on the above proposal.

Public awareness regarding geothermal issues will continue to impact the operation of the geothermal system. The Town is a participant in a Geothermal Advisory Committee, formed to resolve issues among geothermal users. The Town will continue to work with other geothermal users to resolve concerns regarding the geothermal aquifer and the geothermal resource.

CONCLUSION

The geothermal system is presently completing various summer maintenance tasks and preparing for the upcoming heating season. Service connections for new customers will be completed during the month of August. Work will continue on the design and installation of the geothermal discharge water pipeline at the conclusion of the water rights transfer negotiations. When water rights are transferred to the geothermal system, work will commence on providing geothermal heating to even more new customers. The Town will then procure additional monitoring equipment and upgrade its current billing procedure to accommodate additional new customers.

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DISTRICT HEATING SYSTEMS IN ORADEA, ROMANIA

John W. Lund
Geo-Heat Center

BACKGROUND

Oradea is located on the Crisul Repede River, in the northwestern corner of Romania almost due west of Budapest, Hungary. The city has a population around half a million people and can trace its origins back to the Neolithic Age. It was an urban settlement beginning in the 13th century and has been an economic and cultural center for the region. It is a geothermal city with 12 wells drilled within the city limits, six in the nearby Felix Spa and five in the Bors geothermal area to the west, with one doublet set at Nufarul. Currently, there are a variety of geothermal uses in the area, including space and greenhouse heating, domestic hot water supply, process heat, balneology and swimming pools. Wellhead temperatures range from 70 to 105ºC with artesian flows of from 5 to 25 L/s. The present installed capacity is 25 MWt and the heat supply is estimated at 60,000 MWh per year (216,000 GJ/yr). With pumping, the production would double and adding four more doublets, the installed capacity could be increased to 65 MWt.

The utilization of geothermal heat in the city has reduced the air pollution caused by the two local, lignite fired co-generation power plants. The heat supplied from the geothermal sources reduces the emission into the atmosphere of about 300,000 tonnes/year of CO_2, SO_2, NO_x, particles and ash.

The uses of geothermal energy in Oradea are:

- space heating of about 3,000 flats (8,000 people);
- preparation of sanitary hot water for about 6,000 flats;
- milk pasteurization and timber drying;
- fish farming;
- heating 1.8 hectares of greenhouses (additional 7 ha at Borş); and
- electricity generation in a pilot binary plant of 500 kW which uses CO_2 as the working fluid (at the University of Oradea) (Rosca and Maghiar, 1995).

In the surrounding Bihor County, there are 71 geothermal wells serving 20,000 people. This provides about 30% of their space heating and 45% of the domestic hot water.

GEOLOGY

The Oradea geothermal reservoir is located in Triassic limestone and dolomites at depths of 2200 to 3200 m on an area of about 75 km^2 and it is exploited by 12 wells with a total flow rate of 140 L/s geothermal water with temperatures at the wellhead of 70 to 105ºC. The water is of calcium-sulphate-bicarbonate type with mineralization below 0.9 to 1.2 g/L, and no dissolved gases. The Oradea aquifer and the adjacent one at Felix Spa (10 km away) are hydrodynamically connected and are part of the active natural flow of water. The water is about 20,000 years old and the recharge area is in the northern edge of the mountains to the east. Although there is a significant recharge of the geothermal system, the exploitation with a total flow rate of 300 L/s generates pressure draw down in the system, that is presently prevented by reinjection. Reinjection is the result of successful completion and operation of the first doublet in the city at Nufarul, in October 1992. At present, the total installed capacity is over 30 MWt and with the installation of four more doublets, this capacity can be doubled. The Felix Spa reservoir is currently exploited by six wells, with depths between 50 and 450 m. The total flow rate available from these wells is 210 L/s. The geothermal water has a wellhead temperature of 36 to 48ºC and is potable.

The Bors geothermal reservoir is situated about 6 km northwest of Oradea. This reservoir is completely different than the Oradea reservoir; even though, both are in fissured carbonate formations. The surface area is small, only 12 km^2. The geothermal water has 13 g/L dissolved solids and a high scaling potential. Anti-scaling solution (Romanian PONILIT) is injected at 450 m depth and some scale then forms on the pipe (Figure 1). The dissolved gasses are 70% CO_2 and 30% CH_4. The reservoir temperature is greater than 130ºC at the average depth of 2,500 m. Presently, three well are used to produce 50 L/s and two others used for injection at 6 bars. The wells are producing with a temperature of 115ºC at 10-15 bar. The gasses are partially separated at 7 bar, which is the operating pressure, and then the fluid is passed through heat exchangers before being injected. The geothermal water is used for heating 7 ha of greenhouses with an installed power of 15 MWt at an annual savings of 3,000 TOE.

Figure 1. Calcite scaling in Borş well.

CITY DISTRICT HEATING SYSTEM

The Nufarul doublet has been operating over three years to supply domestic hot water through four pumping stations to about 3,000 apartments for 8,000 people near the south east corner of the city (Figure 2). The production well is cased to 2630 m with the last 590 m slotted, and the injection well is cased to 2711 m with the last 426 m slotted. The initial flow rates were 12 L/s from the producer (artesian flow) and 5 L/s in the injector (3-5 bars injection pressure). After acid stimulation, the flow rates increased to 42 L/s from the producer and 8 L/s into the injector, under the same operating conditions. Both wells are vertical and separated by a distance of 950 m. The transmissivity is 72 Darcy-m for the injector.

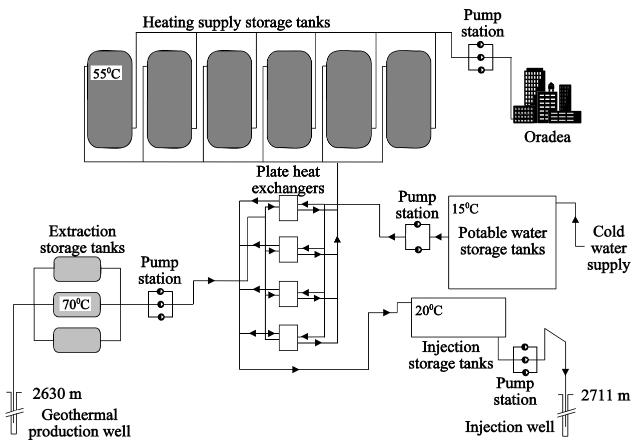

Figure 2. Nufarul doublet and Oradea district heating system.

Although the system has been designed for a geothermal flow rate of 30 L/s and an installed capacity of 5 MWt, the present heat supply is restricted by the deliverability of the production well with artesian flow. At 0.4 bar pressure, the flow rate is limited to 15 L/s (50 m^3/hr) with a wellhead temperature of 70ºC. At these conditions, using a 45ºC temperature drop through the heat exchangers, the present capacity is 2.2 MWt producing 21,000 MWh/yr (75,600 GJ/year).

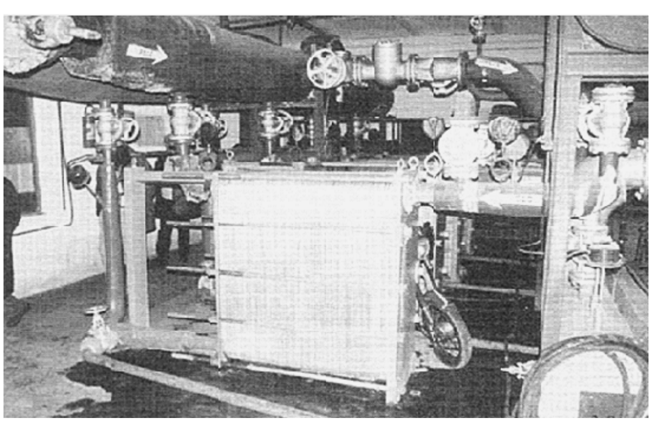

Figure 3. Plate heat exchangers, Oradea district heating sytem.

The fluid from the production well is pumped to three storage tanks and then to four large plate heat exchangers (Figure 3). The geothermal fluid then goes to a 300 m^3 storage tank at 20ºC before being pumped into the injection well at 3.5 bar pressure. Cold city water at 15ºC is first stored in a 1000 m^3 tank before being pumped to the plate heat exchangers. The geothermal fluid heats the city water which is then stored in six vertical tanks totaling 300 m^3 at 55ºC (Figure 4). From these storage tanks the heated water is circulated to the apartments.

Figure 4. Central heat exchanger building and storage tanks, Oradea district heating system.

THE UNIVERSITY OF ORADEA HEATING SYSTEM

The geothermal heating system at the University of Oradea was placed on line in 1981. It provides domestic hot water and space heating for the university campus, and for three apartment blocks located in the vicinity. The campus has 10 main buildings to accommodate about 13,000 students, along with a small greenhouse and several ancillary buildings totaling about 145,000 m^2 of floor space. The National Geothermal Research Institute is housed in one of the buildings. Starting in the fall of 1997, the Institute will provide a one-year specialization program in non-conventional energy sources and in low-enthalpy geothermal energy, along with a post-graduate course in geothermal energy for Romanian and international students (mainly aimed at Central and Eastern Europeans countries) as part of a International Geothermal Training Center. The Institute has also designed and developed a pilot binary cycle power plant using carbon dioxide as a working fluid. The first plant used a piston engine for the working fluid expansion and produced 1 MW of power. A second power plant uses a turbine (Figure 5). Both are experimental installations and therefore, used for testing usually during the warm period of the year when more geothermal water is available for the evaporator (Rosca and Maghiar, 1995; University of Oradea Guide Book, 1997).

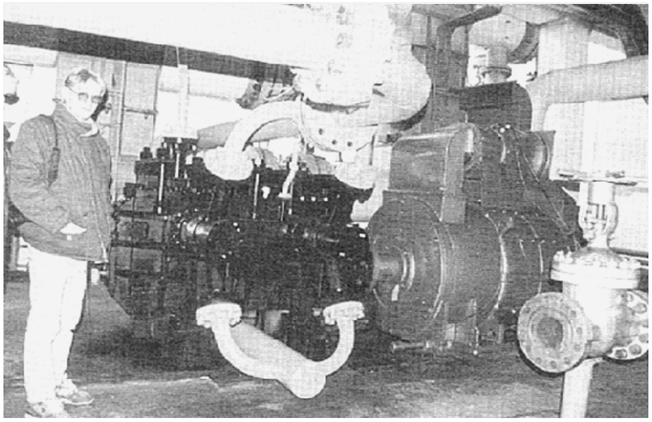

Figure 5. CO_2 binary plant, University of Oradea.

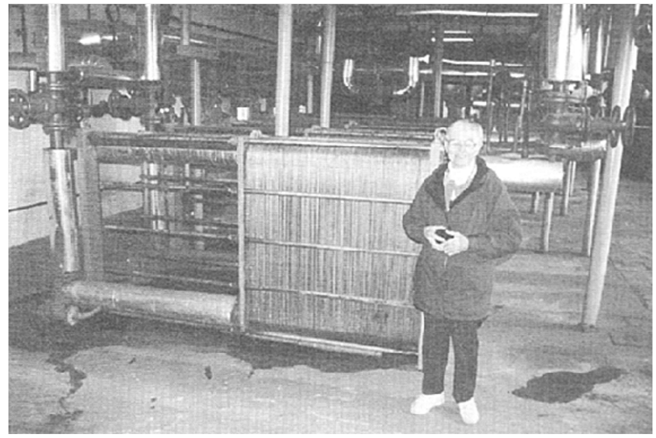

Figure 6. Plate heat exchangers, University of Oradea.

The campus geothermal well is 2991 m deep and produces 85ºC water at an artesian flow of 25 L/s. The water flows into a storage tank and is then piped to the heating station located about 400 m from the well. The thermal energy was originally transferred to the space heating water and to the fresh water in shell-and-tube heat exchangers. In 1994, these were replaced by new stainless steel plate heat exchangers (Figure 6). The heated water then flows through standard cast iron radiators in each room based on a design temperature of 18ºC. The maximum thermal power demand of the heating system is about 3.4 MWt.

The detailed layout of the cascaded system is shown in Figure 7 (Rosca and Maghiar, 1995). The geothermal water is pumped by the deep well pump (DWP) to the storage and degassing tank (SDT) through a surface steel pipe insulated with rock wool and covered by aluminum sheets. The pump is only required when the electric power units are in operation; otherwise, the artesian flow is adequate for the space heating requirements. The tank are kept under pressure to prevent carbonate scaling. The geothermal water is then delivered by pumps (CP1) to the binary electric power unit evaporator (E), the plate heat exchangers (PHX1) for space

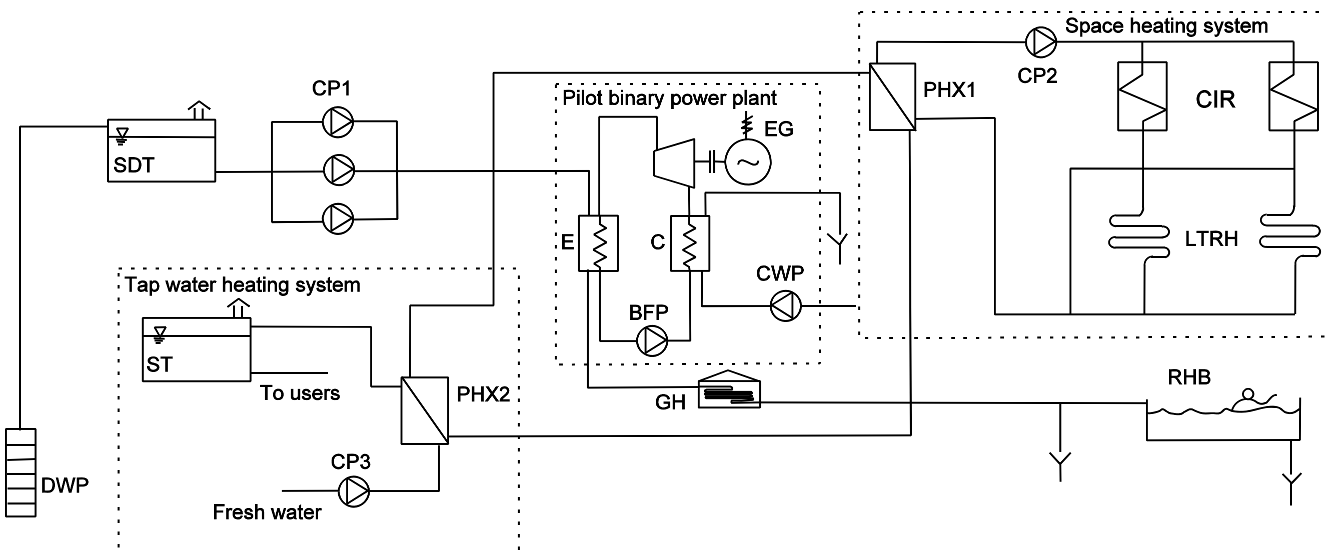

Figure 7. University of Oradea heating system.

heating, and PHX2 for domestic tap water heating. The geothermal water outflow from the evaporator is about 45-50°C, suitable for heating the greenhouse at partial load. The space heating water is circulated by pumps (CP2) first to building cast iron radiators (CIR) and then to low-temperature room heaters (LTRM), or returned directly to the heat exchangers. The domestic tap water is pumped by circulation pump (CP3) to a storage tank (ST) located on top of the highest building. From the ST, the hot tap water is distributed to users by gravity flow. The waste geothermal water is finally used for recreational and health bathing (RHB) in outdoor swimming pools, and an indoor physio-kinetic therapy facility. It is then discharged into a small river running just outside the campus. Since the geothermal water does not contain toxic or polluting chemicals and the river is fed by natural geothermal springs, the surface disposal, thus, has no adverse environmental effects.

The annual savings of this system for tap water heating and space heating is about 65,000 GJ corresponding to an annual fuel saving of about 7,720 tonnes of coal equivalent. This also prevents 24,000 tonnes of CO_2, 34 tonnes of SO_2, 39 tonnes of NO_x, 2,190 tonnes of ash and 6 tons of particles from being released into the atmosphere as compared to a coal fired heating plant.

ACKNOWLEDGEMENTS

Many thanks to the following Romanians who hosted me during my stay in Oradea and for providing information for this article: Ioan Cohut, Marcel Rosca, Adrian Cighir, Adriana Druma, Mioara Laza-Matiuta.

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MILK PASTEURIZATION WITH GEOTHERMAL ENERGY

John W. Lund
Geo-Heat Center

INTRODUCTION

Milk pasteurization with geothermal energy has been viewed by the author in two locations in the world: Klamath Falls, Oregon and Oradea, Romania. The former is no longer in operation; but, the latter has been operating since 1981. A third dairy using geothermal energy has been reported in Iceland (Thorhallsson, 1988) which was established in 1930 to pasteurize milk and evaporate whey to produce brown whey cheese. This dairy merged with another co-op dairy in 1938 and was shut down. A description of the first two of these installations is deemed important, as there is potential for similar installation in other geothermal locations. These two reported savings in energy costs by using geothermal heat; the Klamath Falls installation producing 7,600 L/day (2,000 gals/day) for a savings of $12,000 per year and the Oradea plant producing 70,000 L/day (18,500 gals/day) (winter) and 200,000 L/day (52,800 gals/day) (summer) for a savings of $120,000 per year (saving 800 TOE - tonnes of oil equivalent).

KLAMATH FALLS, OREGON

Medo-Bel Creamery, in Klamath Falls, Oregon, is the only creamery in the U.S. known to have used geothermal heat in the milk pasteurization process (Lund, 1976, 1996; Belcastro, 1979). The geothermal well, located at the corner of Spring and Esplanade streets, was first drilled in 1945 by the Lost River Dairy. The well was designed by a New York engineering firm to insure maximum heat at the wellhead with a minimum of pumping time. The facility was closed down about 10 years ago due to financial problems.

The 233-m deep (765-ft) well was cased to 109 m (358 ft) with 20-cm (8-inch) diameter casing and to 149 m (489 ft) with 15-cm (6-inch) diameter casing. The original well had an artesian flow of around 1.9 L/s (30 gpm) at the surface of 82°C (180°F) water. Based on a recent profile (1974), the well water varied from 80°C (177°F) at the surface to 98°C (208°F) at a depth of 137 m (450 ft), with the artesian surface at one meter (three feet) below the ground level. The geothermal hot water was pumped directly from the well to the building approximately 15 m (50 ft) away through an overhead line. This overhead line allowed easy maintenance and prevented freezing during cold weather since it was self-draining.

Rather than using downhole heat exchangers as is common in Klamath Falls, the water was used directly in air handling units in each room and in the plate-type pasteurizing heat exchanger (Figure 1). The used hot water was then emptied into the storm sewer where it was later used by industry in the south end of the town for cold weather concreting and space heating.

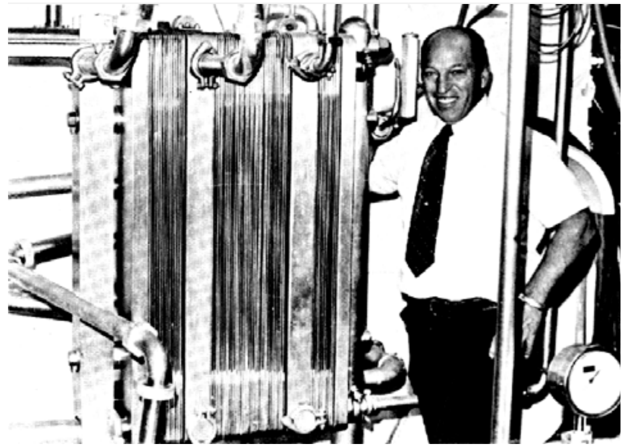

Figure 1. Owner, Elmer Belcastro, standing next to the plate heat exchanger (pasteurizer).

The pasteurization process involved pumping up to 6.3 L/s (100 gpm) of geothermal fluid into the building and through a short-time pasteurizer (Cherry Burrell plate heat exchanger of stainless steel construction) (Figure 2). The geothermal water was pumped from the well at 87°C (189°F) into the building and through a three-section plate heat exchanger. The incoming cold milk at 3°C (37°F) was heated by milk coming from the homogenizer in one section of the plate heat exchanger. The milk was then passes to the second section of the plate heat exchanger where the geothermal fluid heated the milk to a minimum temperature of 78°C (172°F) for 15 seconds in the short-time pasteurizer. If the milk temperature dropped below 74°C (165°F), the short-time pasteurizer automatically recirculated the milk until the required exposure as obtained. Once the milk was properly pasteurized, it was passed through the homogenizer and then pumped back through the other side of the first section of the plate heat exchanger where it was cooled to 12°C (54°F) by the incoming cold milk. It was finally chilled to 3°C (37°F) by cold water in the third section of the plate heat exchanger, where the milk went into the cartons with no chance of cook on. This insured both flavor and longer shelf life. As an added bonus, the outgoing heated milk was cooled somewhat by passing it by the incoming cold milk and the cold milk was in turn heated slightly by the outgoing milk. Milk was processed at a rate of 0.84 L/s (800 gal/hr), and a total of 225,000 kg (500,000 lbs) were processed each month. Some steam was necessary in the process to operate equipment; thus, geothermal water was heated by natural gas to obtain the required temperature. Geothermal hot water was also used for other types of cleaning.

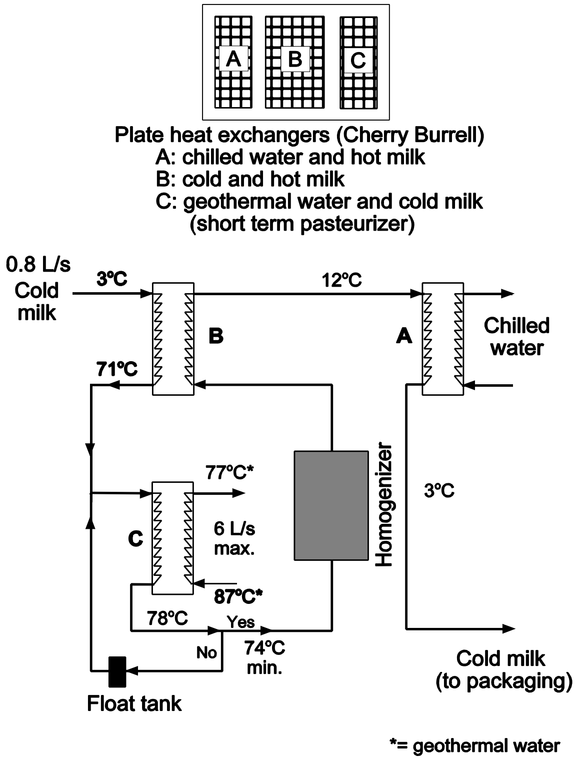

Figure 2. Medo-Bel milk pasteurization flow diagram.

In addition to the milk pasteurizing, some batch pasteurizing of ice cream mix was carried out by geothermal heat. A 950-liter (250-gallon) storage tank was used to mix geothermal hot water and process steam to a temperature of 121°C (250°F). This heat was then used to pasteurize the ice cream mix at 63°C (145°F) for 30 minutes. This was the original milk pasteurizing method used at the creamery.

The geothermal water had slightly over 800 mg/L (ppm) dissolved solids of which approximately half were sulfate, a quarter sodium and a tenth silica. The pH of the water was 8.8. Minimum corrosion was evident in the well, requiring the jet pump to be replaced only once in the 30-year period (1974). The original pump was rated at 0.7kW (one hp) and a new pump was rated at 5.6 kW (7.5 hp). The corrosion had also been minimum in the area heaters and did not affect the stainless-steel plate heat exchanger. Corrosion was substantial in the pipelines.

The annual operational cost of the system was negligible. However, the savings amounted to approximately $1,000 per month as compared to conventional energy costs. Geothermal hot water was also used to heat the 2,800 m^2 (30,000 ft^2) building, which amounted to a substantial savings during the winter months.

ORADEA, ROMANIA

Oradea, a city of almost half a million people, is located in northwestern Romania next to the Hungarian border. There is considerable use of geothermal energy in the area including at Felix Spa just outside of town, district heating systems for a portion of the city and for the university, greenhouses, a lumber drying facility, swimming pools and pasteurizing all the milk for the city. The district heating systems will be discussed in another article in this issue.

The milk factory shares a well used by the lumber drying facility and to heat 100 apartments and several swimming pools (Figure 3). The 3000-meter (9,800-ft) deep well produces 105° to 110° C (221° to 230°F) water at 30 L/s (480 gpm) - "the best well in town." A total of 6 MWt is produced for these facilities. The timber drying facility uses 0.5 L/s to 1.0 L/s (8 to 16 gpm) to produce 50° C (122°F) air to dry 150 m^3 (63,600 board-feet) of lumber in 3 bins (Figure 4) for a period of two weeks to one month for each load. The product is oak which is exported for furniture manufacturing at the rate of about 5,000 m^3 (2.1 million board-feet) per year.

Figure 3. Swimming pool and apartments, Oradea.

Figure 4. Timber drying facility, Oradea.

The milk factory has been using geothermal energy for milk pasteurization since 1981. It supplies all the milk to the city and produces 70,000 L/day (18,500 gal/day) in the winter and 200,000 L/day (52,800 gal/day) in the summer for a savings of about $120,000 per years (800 TOE savings). The raw milk is trucked in daily from surrounding farms (Figure 5). The geothermal fluids is first passed through a series of shell-and-tube heat exchangers which provides secondary water for heating the factory. This secondary water is then passed through plate heat exchangers (Figure 6) to pasteurize the milk. The geothermal fluid is also used to preheat air to produce milk powder. The milk powder requires 300°C (572°F) air for drying (Figure 7). The peak geothermal use for all processes is 17 L/s (270 gpm).

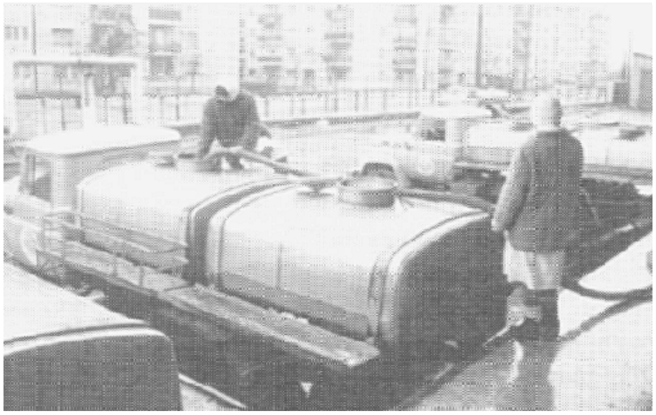

Figure 5. Milk delivery, Oradea.

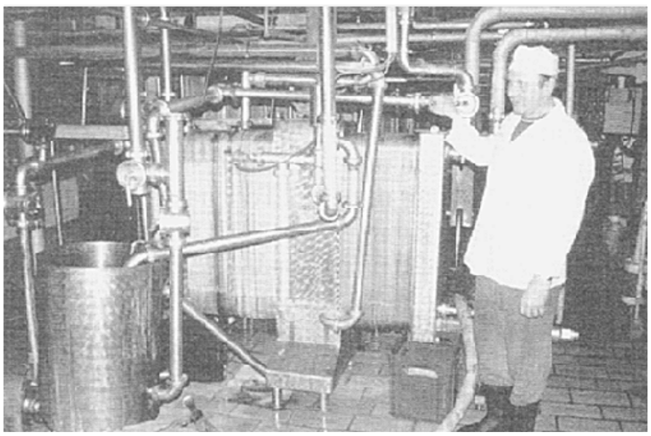

Figure 6. Plate heat exchanger for milk pasteurization.

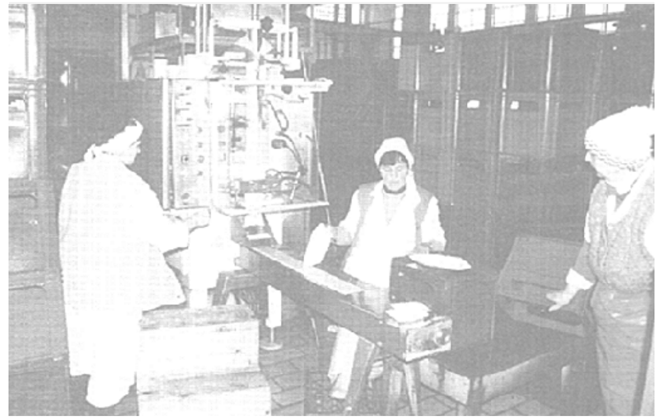

Figure 7. Powdered milk packaging.

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FOUNDATION HOUSE, NEW YORK, GEOTHERMAL HEAT PUMP

John W. Lund
Geo-Heat Center

INTRODUCTION

The Foundation House, planned to house half a dozen nonprofit foundations, will be constructed on 64th Street just east of Central Park in Manhattan, New York. It is in a Landmark District and designed by the architectural firm of Henry George Greene, AIA of Scarsdale, NY (project architect, David Wasserman). The 20,000-square foot building of five floors above ground and two below, will illustrate how energy-saving technology and environmentally sensitive construction methods can be economical. The heating and cooling system, including refrigeration requirements for the freezers and refrigerators in the commercial kitchen, will be provided by geothermal heat pumps using standing column wells. The facility is the first building on the island of Manhattan to feature geothermal heating and cooling. The mechanical system has been designed by Laszlo Bodak Engineers of New York City with the assistance of Carl Orio's firm of Water & Energy Systems corporation of Atkinson, New Hampshire. The two 1550-foot standing column wells were drilled by John Barnes of Flushing, NY.

STANDING COLUMN WELLS

Two 1550-foot, 6-inch diameter wells were drilled into the bedrock below the building at a cost of $100,000 (Figure 1). No serious problems were encountered during drilling and the wells were each completed in five to six days. The 58°F water in the wells will be used to provided both heating and cooling using heat pumps. The standing-column well method takes water from the bottom of the well, passes it through the heat pumps, and then returns it to the top of the well. This vertical movement of water and heat exchange is called a standing column well and provides a convenient and effective heat transfer method as well as the ability to control the Reynolds number of the water/bore surface transfer and a method to create apparently higher transmissivity coefficients. Based on experience by the Water and Energy Systems Corporation, 50 to 60 feet of water column is needed per ton (a nominal 12,000 Btu/hr of cooling) of building load (Orio, 1994). Thus, approximately 30 tons will be obtained from each well for the total estimated building load of 60 tons. It should be noted that the standing column method works best with non-corrosive and non-scaling water, as the water is used directly in the heat pumps. Fortunately, the water in these wells has a low dissolved solids content.

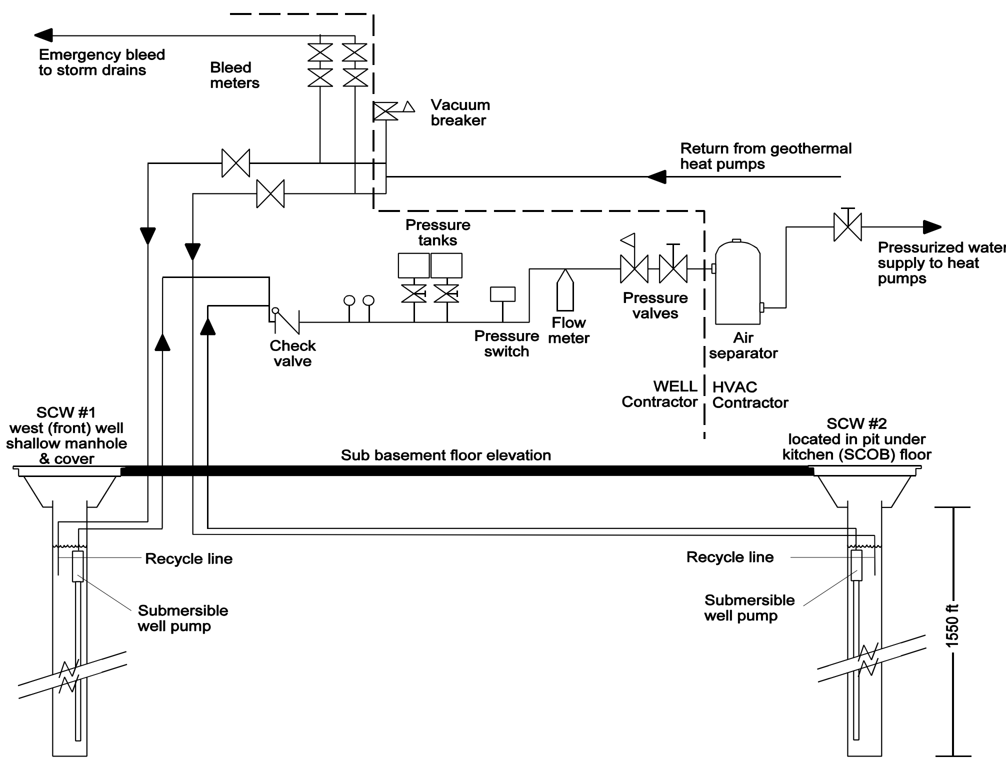

Figure 1. Foundation House standing column well and heat pump system.

The project has also provided information for the U.S. Geological Survey. Their scientists were invited to spend two days probing the underlying 400-million year-old mica schist bedrock. Video cameras and gamma-ray sensors were sent most of the way down the six-inch-diameter holes, providing them with a view of the rock formations, faults and cracks that allow water to percolate through the otherwise solid rock. This information will be used to assist future drilling projects.

HEATING/COOLING SYSTEM

Geothermal heat pumps, manufactured by Climate Master Corporation, will be installed in various function zones in the Foundation House. Each heat pump either extracts energy (heating) from the earth-water system or returns energy to the earth (cooling). Economic advantages are accrued by the winter use of "free" earth energy plus the stored summer heat. Rejected summer heat from air conditioning is readily transferred to the relatively cool bedrock, making the air conditioning more efficient. Summer heat is rejected and stored in the bedrock, without the need for external air condensers, without their familiar attendant noise and without their visible roof-top presence. Quiet geothermal heat pumps have no separate heat rejection devices in this design.

As no fossil fuels are consumed the geothermal heat pumps do not have burning gas emissions. If a fossil fuel heating system had been used at the Foundation House substantial annual carbon dioxide emissions would have been the results. Emissions of carbon dioxide with fossil fuel consumption could have exceed 300,000 lbs of carbon dioxide for oil and nearly 175,000 lbs for natural gas annually.

ACKNOWLEDGMENTS

I would like to thank Carl Orio of Water & Energy Systems Corporation and David Wasserman of Henry George Greene, AIA for their assistance in preparing this article. Additional details on Foundation House and the geothermal system can be found at: http://www.foundationhouse.com.

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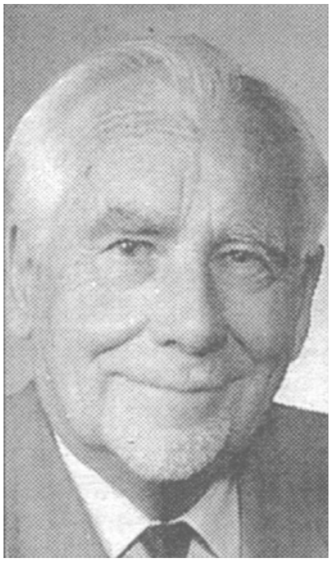
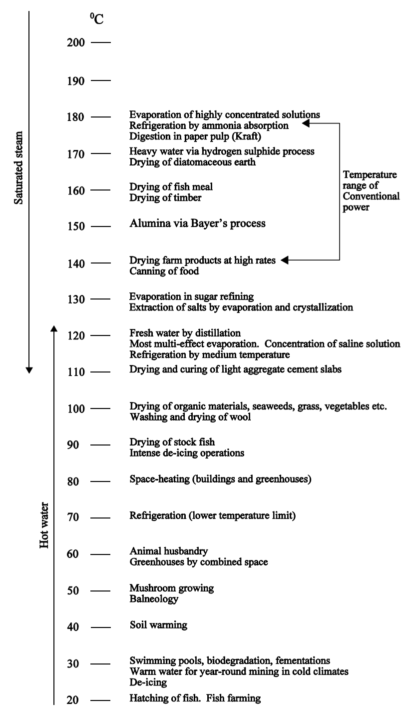
In Memory of Baldur Lindal (1918 - 1997)



Baldur Lindal, one of the world pioneers of direct utilization of geothermal energy, died in Reykjavik (Iceland) on 17th June 1997. He was born at a farm in northern Iceland on 17th August 1918. His father, Jakob Lindal, was a farmer and self-educated geologist. Baldur Lindal graduated as a chemical engineer from Massachusetts Institute of Technology. He worked as an engineer for the Icelandic State Electricity Authority (later Orkustofnun) from 1949 to 1961, and after that, he ran his own consulting engineering office. He soon started working in geothermal research in Iceland and for nearly five decades, he spent endless hours on developing processes for the direct application of geothermal energy for industrial purposes.

He was the prime mover in planning and designing the Kisilidjan diatomite factory at Myvatn in northern Iceland which has been in very successful operation for over three decades producing about 24,000 tonnes per year of diatomaceous earth filter-aids used for clarification of liquids in industry. This plant is the second largest user of geothermal steam for industrial purposes in the world. He was also the key person in developing the Reykjanes sea chemicals plant which produced up to 18,000 tonnes per year of salt receiving both the raw material and the power from a single geothermal well (295°C brine). In addition to numerous experiments in extracting chemicals from geothermal fluids, he was also active to the last day in developing various processes for the chemical industry. Only a few weeks before his death, almost 79 years old, he received a grant from the European Commission for a process development for extracting chemicals out of a certain wild plant.

Although living in Iceland most of his professional life, he participated in the chemical industry and geothermal projects in various parts of the world and was for many years involved in projects in Africa, Europe, USA, Central America, and the Middle East. He published a large number of papers on the direct application of geothermal energy and was for decades an active participant in international geothermal conferences including one on the OIT campus in 1974. His diagram indicating the temperature range of geothermal water and steam suitable for various applications has become a classic and is generally referred to in the literature as the "Lindal Diagram" (Gudmundsson, J.; Freeston, D. and P. Lienau, 1985. "The Lindal Diagram," GRC Transactions, Vol. 9, pp. 15-17). It was first published in 1973 in Lindal's article "Industrial and Other Uses of Geothermal Energy," in a book entitled *Geothermal Energy* published by UNESCO in Paris. He was a member of the International Geothermal Association (IGA) and the Geothermal Resources Council. On behalf of the International Geothermal Association, I would like to thank Baldur Lindal for his great contribution to geothermal development worldwide. Condolences are sent to his wife and family.



Ingvar B. Fridleifsson, President of IGA, Reykjavik, Iceland

GEOTHERMAL PIPELINE

Progress and Development Update
from the Geothermal Progress Monitor

OIT's GEO-HEAT CENTER DIRECTOR PAUL LIENAU RETIRES

Paul J. Lienau retired as Director of the Geo-Heat Center at Oregon Institute of Technology (OIT) on June 30. He held the position since the Center was established in 1975; John W. Lund assumed the position on July 1.

Paul's career in geothermal energy utilization began in 1974, when he co-chaired the *International Conference on Geothermal Energy for Industrial Agricultural and Commercial-Residential Uses*--the first international conference held in the United States that was devoted to direct applications of geothermal energy.

Interest in low-to-moderate temperature geothermal resources generated by the 1974 conference prompted establishment of the Geo-Heat Utilization Center (now the Geo-Heat Center) the following year.

A faculty member of the OIT Physics Department at the time, Paul's interest in geothermal energy persuaded him to move into the new center--at first on a part-time basis, and within a year as full-time director. The Center's first publication, edited by Lienau and Lund, covered the 1974 conference. The *Geo-Heat Center Quarterly Bulletin*, which debuted shortly afterwards, is now in its 22nd year, with 70 issues and 2,400 subscribers. Paul and John have been co-editors of the publication since its inception.

As Geo-Heat Center Director, Paul has been active in many research projects, most of them funded by the U.S. Department of Energy. He has lectured for the Geothermal Institute, University of Auckland New Zealand (1982) and for the Geothermal Research and Training Center, University of Tianjin, P.R. China (1988).

Paul has also been active with the Geothermal Resources Council (GRC) as a field trip leader and annual meeting session chair, and has presented a number of technical papers at council events. His most recent project involved coordinating a "Low-Temperature Resource Assessment of 10 Western States," and helping complete a "Ground-Source Heat Pump Case Studies and Utility Program." In 1993, the GRC awarded the Geo-Heat Center with its Geothermal Special Achievement Award.

Paul also contributed two chapters to the Geo-Heat Center's publication, *Geothermal Direct Use Engineering and Design Guidebook*, one of the most important technical assistance publications on the subject. The Guidebook is currently being revised and updated.

Paul has retire with his wife, Colleen, to Camano Island in the Puget Sound area of Washington State. Along with ample time reserved for golf and fishing, he plans to help his son, Mike, with various video projects--including continuing work on Mount St. Helens.

MEETINGS

Geothermal Resources Council Annual Meeting, Hyatt Regency, San Francisco Airport (Burlingame), October 12-15, 1997. Contact GRC, PO Box 1350, Davis, CA 95617 (Phone: 916-758-2360).

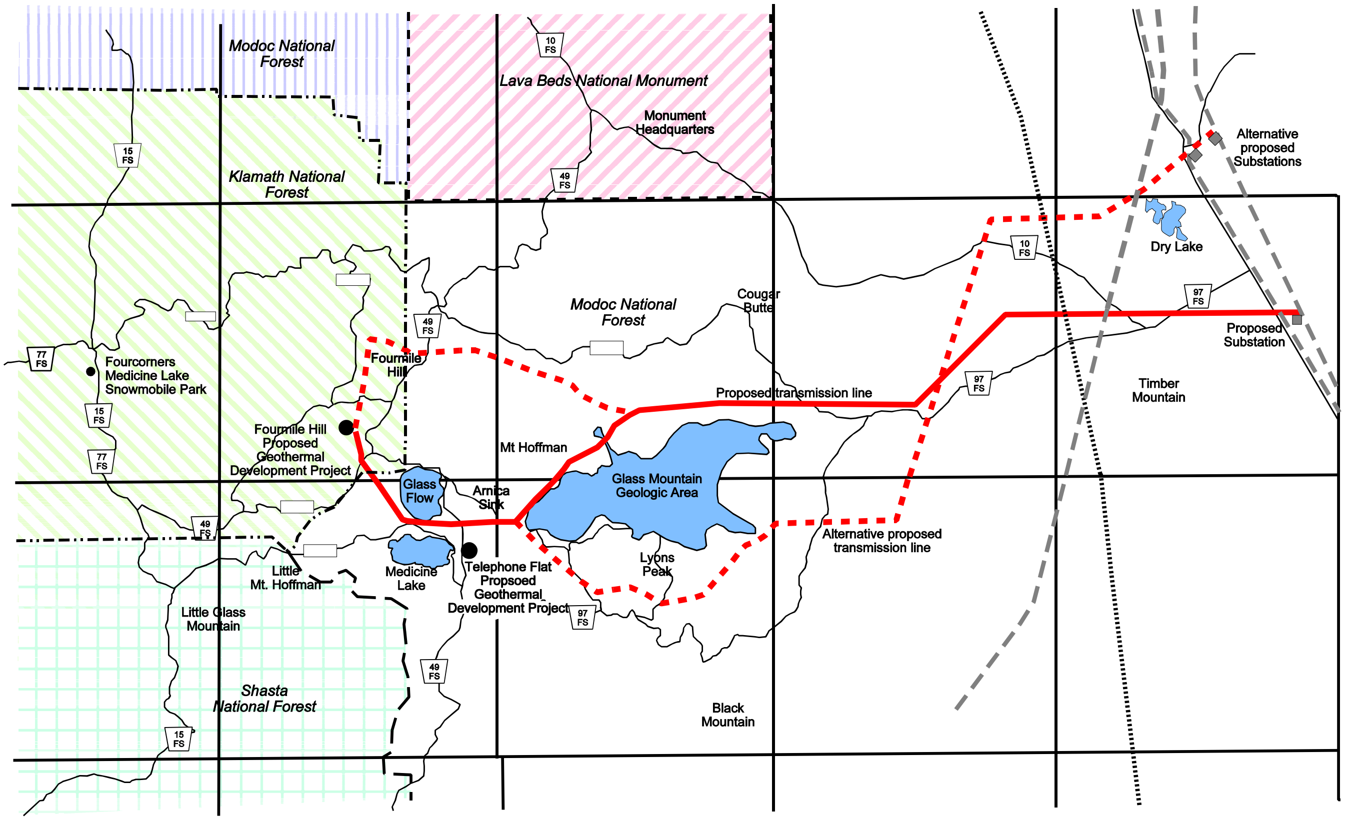
Optimization of Geothermal Drilling and Field Performance, Cerro Prieto Geothermal Field, Mexicali, B.C., Mexico, September 4-5, 1997. Contact GRC, PO Box 1350, Davis, CA 95617.

CALIFORNIA

Proposed Medicine Lake Power Plants Under EIS Review

Two geothermal power plants are being proposed for the Medicine Lake/Glass Mountain area in northern Siskiyou County. The Fourmile Hill Geothermal Project, being proposed by Calpine Corp., of San Jose, is outlined in a draft environmental impact statement now available for public comment. The plant, which would generate 49.9 MW will be located on Klamath National Forest land. The BLM and Forest Service will accept public comments on the proposed project through September 16th, and public hearings have been scheduled in Dorris, Yreka and Klamath Falls. A decision on whether to allow construction could come later this year, with well drilling to begin next year. If tests confirm the viability of the geothermal resource, construction of the power plant could being in 1999 or 2000. The plant would have an expected life span of 45 years, and would be dismantled after being decommissioned. Construction of the power plant would involve disturbance of 388.5 acres of land, including 335.8 acres for the transmission line right-of-way and access roads. The power plant would occupy a 10-acre site; while, seven well pads would require disturbance of 18 acres. About 25 acres would be disturbed by pipelines, roads and construction of a new substation. A 230-kilovolt transmission line would tie into a BPA transmission line to the east (see map on next page). Even though BPA has canceled a contract to buy power from the facility, Calpine Corp. spokesperson says it hopes to market the power, which results in very low emissions of air pollution, as environmentally-friendly "green energy."

Employment during the construction of the plant would increase from about 15 construction workers in the first year to 160 at the peak of construction, expected in the third year. Calpine estimate the plant would be staffed by 19 permanent employees, with an annual payroll of $1.2 million. The company would pay an estimated $1.3 million in property taxes annually during the first five years of operation, with



payments declining gradually as the plant ages. Another $15 - $25 million in royalties would be paid to the federal government, which would return half the money to the state of California. Of the state's share, 40 percent would be distributed to the counties where the power plant and transmission lines are located.

A second proposed project, also just under 50 MW, will be constructed by CalEnergy Co., of Omaha, Nebraska. The Telephone Flat proposal is about six months behind the CalEnergy project; thus, the draft EIS report will not be available for public comment until later this year. This plant, also a double-flash steam power generating facility, will be constructed on the other side of Medicine Lake. The power will be transmitted by a connection to the Calpine power line (see map). (Todd Kepple - *Herald and News*, July 18, 1997)

OREGON

BPA Pays Nearly $175 Million

The Bonneville Power Administration has agreed to pay nearly $175 million from ratepayers to back out of energy generation projects since 1995. The total includes $30 million in confidential settlements that Bonneville made in December with two California companies who had agreed to build geothermal plants on the federal agency's behalf. In one case, BPA paid $12 million to withdraw from a geothermal project without informing its partner, the city of Springfield's utility, that is was abandoning the deal, court records show. The Springfield Utility Board has since gone to court to challenge BPA's action and make public the still-secret settlement that BPA signed. Bonneville Administrator Randy Hardy said that projections of growth beyond what BPA could generate had prodded the agency to take on these deals a few years ago. It would cost Bonneville more to stay in those projects than get out, he said. "To continue with these projects would have been to endure economic hardship for northwest ratepayers," Hardy said. Jeff King, an energy resource analyst with the Northwest Power Planning Council, said Bonneville's assessment might be correct. "Bonneville might find it needs these power resources for the long term; but, the answer from a business point of view may be that it needs to survive in the short term to do anything at all in the long term," King said. One of the geothermal projects that BPA is buying out of is near Vale in Malheur County, which was a joint project with the Springfield Utility Board. When test wells at the Vale Site failed to find enough steam to run the plant, the original developer sold its interest to Calpine Corp. of San Jose, CA. Calpine chose to move the project to Glass Mountain (Medicine Lake) in northern California, which is still within BPA's marketing area. In December, BPA ended its commitment to this facility at a cost of $12 million.

The second geothermal project was proposed for Newberry Crater in Deschutes County, near Bend, OR. CalEnergy Co. of Omaha, Nebraska, had proposed a 30-MW plant at this site. BPA would buy two-thirds of the plant's power and subsidize the purchase of the remaining power for the Eugene Water and Electric Board (EWEB). In August

1996, CalEnergy claimed that its test well at Newberry showed the site didn't produce enough steam. As with the Calpine deal, CalEnergy had the right to move the project to Glass Mountain in California and BPA was obligated to buy the power. Bonneville, however, balked at staying in the deal, and thus, are proposing to pay $9 million to get out at a future date and an additional $9 million if it chooses not to buy the power. (Brent Walth - *Oregonian*, May 18, 1997)

Geothermal Hookup for New County Building

The new Klamath County Courthouse and administration building may be heated by geothermal. The original building, damaged beyond repair in the magnitude 6.0 earthquake in 1993, is being torn down to make way for the new $17-million building. The county is presently deciding if they should hook on to the city of Klamath Falls' geothermal district heating system. This system, supplying 180°F water to the downtown area, provides heat for a number of other governmental buildings and for sidewalk snow melting. The final design should be completed this summer and construction starting shortly afterwards.

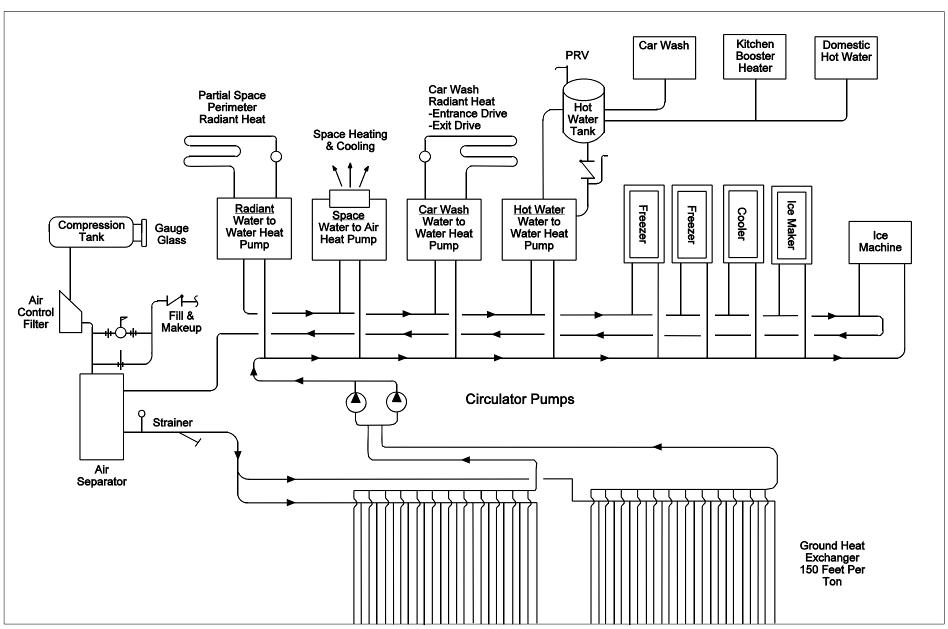
Australian Red Claw Crayfish Farm

AquaFarms, owned by James G. Lewis and his partner, will soon raise Australian red claw crayfish on 20 acres just west of Hunter's Hot Springs and Family Resort in Lakeview. Ground breaking was in May. Plans call for a dozen raceways to be built over the next three years. Each raceway will measure 370 feet in length and 16 feet in width, enough space to raise more than 100,000 crayfish--with an annual production of almost 1.25 million crayfish. Each raceway will be housed inside a greenhouse with extra space dedicated to a still undetermined medicinal cash crop. Inside each greenhouse will be two tanks. One tank is for the brood stock. The other one is for brine shrimp, the crayfish's chief food source. The shrimp are 60 percent protein, which accelerates growth. Mr. Lewis estimates he'll need to raise 15 tons (at 6,000 shrimp to the pound) over the next eight months to meet the crayfish's demands. Other potential markets include the Philippines and other Pacific Rim countries. Geothermal water in the area is around 200°F, with a minimum of 70°F needed for the crayfish to survive. (Source: *Herald and News*, June 22, 1997)

MINNESOTA

Heat Pump Installation for Gas Station/Convenience Store

A ground-coupled heat pump system has been installed in a Conoco/Petro Plus gas station and convenience store in Sandstone. The installation is expected to save about 25% ($5,000) of the typical annual energy cost of space heating and cooling, and water heating. The geothermal system has a simple-payback of between four and six years, according to Minnesota Power. The 4,300-sq-ft store will use three heat pump with ground loops of 24, 150-ft deep wells dug 20 feet apart (150 ft per ton of capacity)(see figure below). The integrated geothermal system uses a piping arrangement that circulates water through two water heating heat pumps, one space heating and cooling heat pump for the store area, a walk-in cooler, two freezers, ice machine, and the earth heat exchangers. The loop system is a heat source for the car wash water heating, domestic water heating, radiant heating in the car wash floor, and snow melting under the car wash's entrance and exit areas. The waste heat from the refrigeration units supplements the 22-ton (77.4 kW) system's output with 75,000 Btu per hour to the loop. The mechanical contractor is Gary Drilling. (Source: *ASHRAE Journal*, June 1997)



Schematic of integrated geothermal system.

PENNSYLVANIA

Heat Pump Installation for a Nursing Home

One hundred and twenty wells will be dug in the site of the new 360-bed Neshaminy Manor in Doylestown Township. The wells will extend to a depth of 479 feet to tap a constant ground temperature of 54ºF. A ground-source heat pump (GSHP) will be installed to control the climate in the new nursing home. The 160,000-sq ft building will use the earth for heating and cooling with a 20-year savings of $3 million. The system is designed by Energy Performance System, Inc. To install a boiler system would cost $3.8 million, with a cost of $227,000 annually to operate and $71,000 to maintain. The geothermal system will cost about $3.7 million to install, but $143,000 to operate each year and $33,000 to maintain--providing the $3 million savings. The total building cost is $19.5 million. (Source: *Allentown Morning Call*, June 9, 1997)

CHINA

An underground "pool" of hot water with more than 220 billion cubic meters of geothermal reserves has been found under Tianjin in north China. The 8,700-sq-km "pool" makes the city the largest of the medium- and low-temperature geothermal resource-rich regions in China. The reserves lie from 60 to 3,000 meters deep, and have high mineral contents, moderate temperatures, and are suitable for daily use. More than 100 million yuan ($12 million) has been spent verifying the reserves since the 1970s. The city has drilled 150 wells and has extracted 15 million cubic meters of hot water annually. The three near-surface geothermal "pools" alone provide enough water for central heating for three million square meters of residences. Another result has been that the Tanggu District was able to shut down 581 boilers and more than 500 chimneys. More than 100,000 people use the geothermal water in their daily lives. Tianjin has expanded the use of the geothermal heat from industry and central heating to greenhouses, aquatic products, therapeutic purposes, mineral water development, and scientific research. The city has adopted some regulations to protect and maintain these resources. (Source: *Xinhua English Newswire*, June 18, 1997).