INN OF THE SEVENTH MOUNTAIN
BEND, OREGON

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BUILDING CHARACTERISTICS

The Inn of the Seventh Mountain is a hotel/condominium complex located approximately seven miles (11 km) from Bend, Oregon, on the road to the Mt. Batchelor ski area, about 175 miles (280 km) south of Portland. The Inn was first built in 1972, and consists of 22 individual condo buildings containing 350 units for a total of 248,800 ft^2 (23,115 m^2). The complex contains restaurants, a conference center, ice rink, spa, and other amenities common to a first-class destination resort. The complex is of wood construction. Heat was originally provided with resistance electric ceiling heat. Most of the lodging units are three stories. The buildings were built to meet the energy codes of the early 1970s, and according to operation staff under insulated. Windows are all double-paned.

GEOTHERMAL HEAT PUMP SYSTEM CHARACTERISTICS

A process schematic is shown in Figure 1.

Geothermal Source Description

The geothermal source is provided by one well located close to the central heat pump plant. Water flow is 1,150 gpm (72.5 L/s) at 50ºF (10ºC). The production well is 400 ft (122 m) deep. Pumping is provided by a 225-hp (168 kW) variable speed pump. After passing through heat exchangers (Figure 2), the water is disposed of through an injection well located near the edge of the property.

Heating, Ventilation, and Air Condition (HVAC) System Description

The central heat pump system consists of two 250-ton (879-kW) screw compressor heat pump/chillers (Figure 3). Originally, when the retrofit to heat pumps took place in 1992, one 300-ton (1053 kW) centrifugal unit was installed but, because it was oversized, it continued to surge and would not stay on-line. The two 250-ton (879-kW) screw compressors have proven to be much more satisfactory. The heat pump/chillers are separated from the geothermal source through the use of two plate and frame heat exchangers. Distribution of hot [ca 115ºF (46ºC)] or chilled [50ºF (10ºC)] water is via a four-pipe distribution system. The distribution system is centrally controlled for optimum temperature balance and energy use. The four-pipe system supplies fan coil units distributed throughout the condo units and other buildings. Hot water from the distribution system also preheats the domestic hot water supply to buildings. The swimming pool, spa tubs, and the bath house are also heated by the heating loop. The chilled water loop serves as the condenser water for the ice ring.

SELECTION OF THE GEOTHERMAL HEAT PUMP SYSTEM

By the late 1980s, the 1972 complex was beginning to experience problems with the ceiling electric resistance heating units, and there was an increasing need to be able to provide air conditioning during the summer months. The owners first looked at replacing the system with gas heating and gas absorption cooling. The servicing electric utility,

however, recommended the geothermal heat pump option as a means to meet both heating and air conditioning requirements and provided incentives to the owners. The conversion was made at an investment of ca $3 million. The conversion project resulted in a 49 percent savings in metered energy, but only a 3 percent savings in energy costs. However, it must be remembered that the system now also provides air conditioning that was not provided by the system replacement.

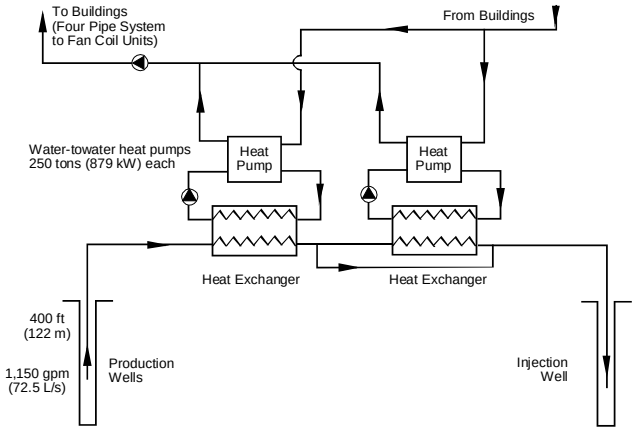

Figure 1. The process schematic for the Inn of the Seventh Mountain.

Figure 2. Photograph of one plate and frame heat exchanger at the Inn of the Seventh Mountain.

OPERATING HISTORY

When the conversion from electric ceiling resistance units to a central geothermal heat pump system was made, the decision was made to go with one 300-ton (1053 kW) centrifugal heat pump/chiller. This, however, proved to be a poor choice, and during light loads, the unit was considerably oversized and continued to surge and would not stay on-line. After only a short period of time, it was decided to replace the 300-ton (1053 kW) centrifugal unit with two 250-ton (879 kW) screw compressor units. These units also suffered some initial problems due to faulty thrust bearings, and both motor assemblies had to be replaced within the first year. However, after these initial design and equipment problems, the system has operated as expected and with minimal operational or maintenance problems.

Figure 3. Photograph of one of the water-to-water heat pumps at the Inn of the Seventh Mountain.

The only short coming of the system is that there is no central control over thermostats in individual condo units, thus when units are not occupied, there is no way to monitor or control temperature levels. This has resulted in many unoccupied units being heated or cooled needlessly and, of course, with a substantial waste of energy and with a significant cost penalty.

OPERATION AND MAINTENANCE

The system has operated extremely well since initial problems associated with the centrifugal heat pump/chiller and motor thrust bearings were solved. In neither case was the problem a result of or caused by the geothermal source. Maintenance and operation are both taken care of by an experienced and very competent in-house staff.

SYSTEM ECONOMICS

The $3 million retrofit to geothermal heat pumps resulted in a 49 percent reduction in metered electrical energy consumption, and a 3 percent reduction in overall energy cost, while at the same time providing air conditioning. The total energy consumption for the facility is 24.47 kWh/ft^2/yr (263.4 kWh/m^2/yr), while the heat pump plant uses 10.14 kWh/ft^2/yr (109.1 kWh/m^2/yr). Annual maintenance cost for the past several years have averaged approximately $0.18/ft^2 ($1.94/m^2). The annual energy usage as well as the maintenance cost is somewhat of an over estimate, as the system also provides heating to two

swimming pools and the spa pools, and the chilled water. loop serves as the condenser water for the ice ring.

SATISFACTION WITH THE GEOTHERMAL HEAT PUMP SYSTEM

Operation and maintenance staff are both extremely happy with how the system has operated and the lack of maintenance problems that have occurred. The system seems to provide a high level of comfort to guests. It would appear that even greater energy and cost savings would be possible if the system were set up so that individual units could be monitored and thermostats adjusted when the units were unoccupied for any extended length of time.

ACKNOWLEDGEMENT

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OVERALL SUMMARY

Building Description:

Location: Bend, OR
Occupancy: Hotel/condominium resort
Gross Floor Area: 248,800 ft^2 (23,115 m^2), 22 buildings
Type of Construction: Retrofit
Completion Date: Buildings in 1972, heat pump retrofit in 1992
July Avg. High Temp.: 81.7°F (27.2°C)
Jan Avg. Low Temp.: 23°F (-5.0°C)
Annual Heating Degree Days: 4490°F-day (2494°C-day)
Annual Cooling Degree Days: 12°F-day (7°C-day)

Interior System:

Total Installed Heat Pump Capacity: 500 tons (1758 kW)
No. of Heat Pump Units: 2 water-to-water
Heat Pump Capacities: 250 tons (879 kW)

Ground-Source System:

Type: Open loop
Mean Groundwater Temp.: 50°F (10°C)
Configuration: 1 production well, 1 injection well
Well Depths: 400 ft (122 m)
Pumping Rates: 1,150 gpm (72.5 L/s)

Economic Analysis:

Installed Geothermal HVAC Capital Cost:
$3 million
Total Annual HVAC Energy Use:
10.14 kWh/ft^2 (109.1 kWh/m^2)
Total Annual HVAC Energy Savings:
49% plus the additional benefit of cooling
Annual Maintenance Costs:
$0.18/$ft^2$ ($1.94/$m^2$)

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