CALPINE GEOTHERMAL VISITOR CENTER MIDDLETOWN, CALIFORNIA

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Geo-Heat Center

LOCATION & BACKGROUND

The Calpine Geothermal Visitor Center is located in Middletown, California, about 70 miles (113 km) north of San Francisco. It is a single-story, 6,000 ft^2 (560 m^2) building and is the visitor center for The Geysers geothermal field, the largest geothermal power generating operation in the world. The visitor center building has incorporated a number of "green" features, one of which is a geothermal heat pump system. Completed in 2001, the building has a lobby area, an exhibit hall featuring geothermal power displays, small offices, a conference room, a kitchen, and a multipurpose room (Figure 1).

Average high temperatures in the area in July are about 92°F (33.3°C) and average low temperatures in January are about 35°F (1.7°C). There are approximately 2800 heating degree days and 800 cooling degree days per year [65 °F (18°C) base].

SYSTEM DESCRIPTION

Ground Source System

The ground source system (shown in Figure 1) is the vertical closed loop type consisting of 20 vertical boreholes, each 225 ft (69 m) deep, for a total length of 4500 ft (1372 m). The boreholes are installed in a 4 x 5 grid pattern with 20-ft (6.1-m) spacing. A single u-tube heat exchanger is installed in each borehole and the heat transfer fluid is pure water. The borehole field is piped in a reverse-return arrangement.

The mean annual ground temperature in this location is about 62°F (16.7°C). The loop field was installed in an alluvial fan deposit, consisting of cobbles and boulders.

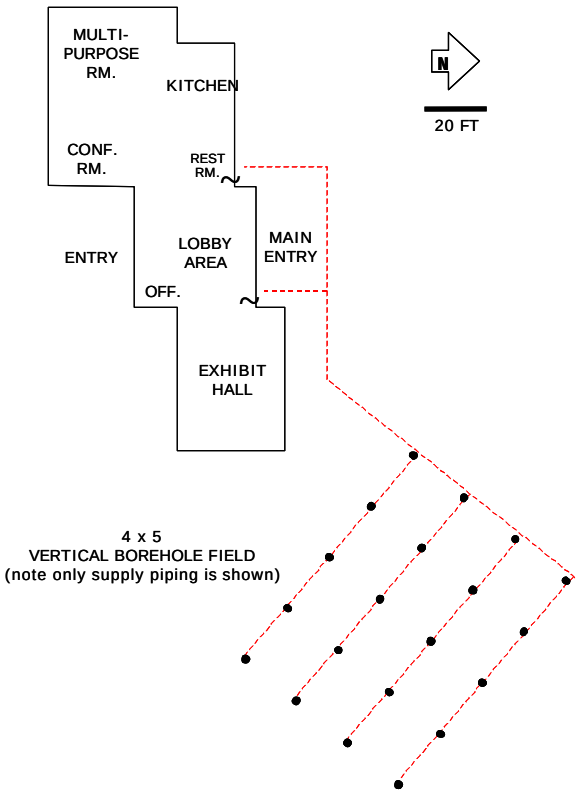

Figure 1. Calpine Visitor Center site sketch showing ground loop field.

Interior System

The total installed heat pump capacity is approximately 25 tons (88 kW). As each room in the building has a different use and variable occupancy rate, the building was designed so that each room is a separate zone. Space conditioning for the lobby, offices, and exhibit hall is accomplished with vertical water-to-air heat pumps installed in closet spaces. Space conditioning for the other areas (conference rooms, hallways, restrooms, and kitchen) is done with horizontal water-to-air heat pumps hidden in the attic. Ventilation air is ducted through the attic space to individual heat pumps. A 1 ton water-to-water heat pump installed in the kitchen is used for domestic hot water heating. For energy efficient pumping, a separate water circulator is installed on each heat pump. A schematic of a typical heat pump layout is shown in Figure 2, and a photograph of the 6-ton (21 kW), vertical unit and flow center serving the exhibit hall is shown in Figure 3.

PROJECT COSTS

The total geothermal heat pump heating, ventilating, and air-conditioning (HVAC) system cost in 2001 was $78,000, or approximately $13/ft^2 ($140/m^2). From Means construction cost data (2000), the median HVAC system cost for a similar building (a community center) is $9/ft^2 ($97/m^2). Therefore, it is estimated that the geothermal heat pump system capital cost was about 44%, or $24,000 greater than a conventional system.

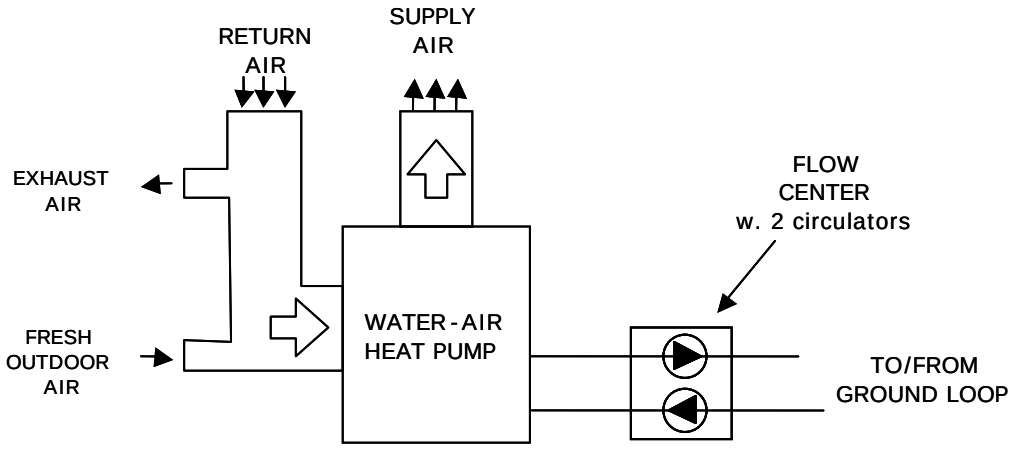

Figure 2. Schematic of a typical heat pump at the Calpine Visitor Center.

Figure 3. Photograph of a 6-ton, water-air, vertical heat pump and flow center.

SYSTEM PERFORMANCE AND OPERATING COST

Electrical energy consumption for the Calpine Visitor system for the year 2004 is shown in Figure 4. The data shown in Figure 4 represent the total electrical energy consumption for the building, and therefore the exact HVAC system energy use is not known. The total electrical energy consumption for 2004 was 80,120 kWh.

In order to compare performance of the geothermal heat pump system to a conventional HVAC system, the building performance was simulated using eQuest, which employs the DOE-2 building simulation engine. For this simulation, building use and occupancy profiles for a community center were chosen. The conventional HVAC system modeled was a multi-zone rooftop unit with forced-air natural gas heating and DX cooling.

Results of the simulated energy consumption of the conventional system are shown in Figure 5. A review of Figure 5 shows that a conventional HVAC system at the Calpine Visitor Center would consume a total of 86,400 kWh of electrical energy and a total of 597.65 million Btu (63 GJ) of natural gas.

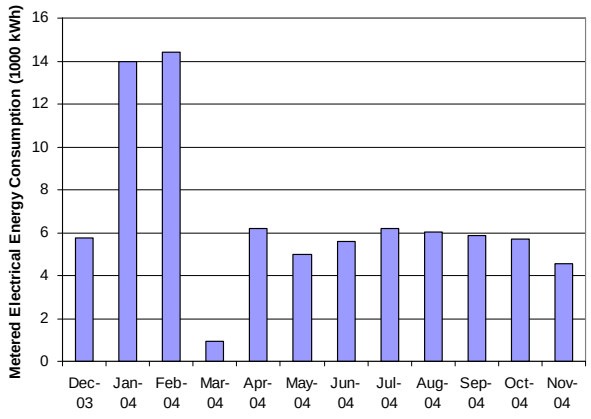

Figure 4. 2004 metered electrical energy consumption for the Calpine Visitor Center (note this is all electrical energy use for the building).

Assuming an average cost of electricity of \$0.10/kWh and an average natural gas cost of \$0.85/therm (\$0.3/m^3), the annual energy cost for the conventional system would be \$8,640 for electricity and \$5,080 for natural gas, giving a total annual cost of \$13,720. This is about 58% higher than the 2004 cost of \$8,640 from the metered use, giving an estimated annual savings of about \$5,080. Neglecting maintenance costs, this savings amounts to a simple payback period of 4.7 years.

OPERATING EXPERIENCES

Calpine reports that the drilling was more difficult than expected due to the presence of large cobbles and boulders underlying the site. This resulted in drilling costs in excess of original estimates.

The only operating difficulty to date is that not enough cooling was provided to the kitchen. This difficulty, however, is not attributable to the heat pump system, but to an oversight in the estimation of the kitchen cooling load.

OVERALL SUMMARY

Building Description:
Location: Middletown, California
Occupancy: Visitor Center
Gross Floor Area: 6,000 ft^2 (560 m^2)
Number of Floors: 1
Type of Construction: New
Completion Date: 2001
July Avg. High Temp.: 92°F (33.3°C)
Jan Avg. Low Temp.: 35°F (1.7°C)
Annual Heating Degree Days: 2800°F-day (1550°C-day)
Annual Cooling Degree Days: 800°F-day (444°C-day)

Interior System:
Total Installed Heat Pump Capacity: ~25 tons (88 kW)
No. of Heat Pump Units: 10
Heat Pump Capacities: 1 to 6 tons (3.5 to 21 kW)
Pumping System: Individual flow centers
Additional notes: Water-to-air heat pumps for space conditioning
Water-water heat pump for domestic water

Ground-Source System:
Geologic Materials: Alluvial sediments
Mean Ann. Ground Temp.: 62°F (16.7°C)
Type: Vertical closed loop, single U-tube
Configuration: 20 boreholes (4x5 grid pattern)
225 ft (69 m) deep,
20 ft (6.1 m) spacing
Borehole per ton: 180 ft/ton (15.6 m/kW)
Heat Transfer Fluid: Pure water

Economic Analysis:
Installed Geothermal HVAC Capital Cost:
\$78,000 (\$13.00/ft^2)(\$140/m^2)
Estimated Conventional HVAC Capital Cost:
\$54,000 (\$9.00/ft^2)(\$97/m^2)
Total Building Energy Use:
80,000 kWh
Simulated Conventional Building Electrical Use:
86,400 kWh
Simulated Conventional Building Gas Use:
598 million Btu (63 GJ)
Estimated Simple Payback Period:
<5 years

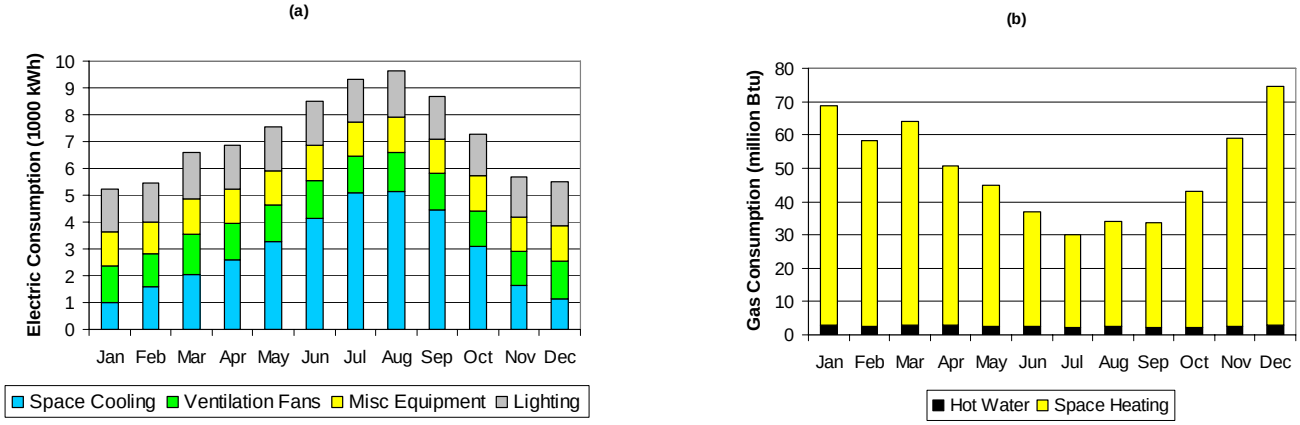

Figure 5. Simulated energy consumption of a conventional multi-zone rooftop unit with forced air natural gas heat and DX cooling: a) cooling with electricity, and b) heating with gas.