Federally Sentenced Women's Facility, Truro, Nova Scotia

Federally Sentenced Women's Facility

Committed to reducing carbon dioxide (CO_2) emissions caused by fossil fuel combustion attributed to its activities, the Correction Service, Canada (CSC) installed 60 tons of GeoExchange[SM] (geothermal) heating and air conditioning at its new Federally Sentenced Women's Facility in Truro, Nova Scotia. The facility also saves the CSC an estimated $8,300 in annual energy costs over a conventional system of high-efficiency propane boilers and split-system air conditioning.

Completed in 1994, the complex of 12 one- and two-story buildings, many of them linked, includes stand-alone residential units, and a gymnasium, recreation building, education building, offices, health and food services, and an enhanced security building. Full occupancy is about 35 inmates and staff.

The project is applicable to both residential and commercial building applications, according to mechanical designer Stephen Tweedie of Enerplan Consultants, Ltd. in Moncton, New Brunswick.

Although actually a small institution, parts of the 41,300-square-foot project were built with materials more typical of residential construction, such as wood and dry wall. The architectural design closely followed the Advanced House and C2000 Commercial program guidelines for energy and environmental efficiency. The insulation, window glazing, etc. resulted in buildings that were quite energy efficient from the start.

"The whole facility has been quite an experiment from the beginning," Tweedie says. "And the results have been quite encouraging from both a cost perspective and an operations point of view as well."

System Description

A monitoring project is in place to collect data on numerous facets of the GeoExchange system's

System Features

- Mixed closed loop (vertical, slinky, spiral)
- Twenty-four boreholes 72 - 289 feet deep
- 650-foot horizontal trench
- Ground loop flow rate: 24 gpm
- Two 1½-hp pumps
- Solar water heaters preheat service water and provide heat to ground loop
- Waste heat from refrigeration system rejected by ground loop
- Heat recovery ventilators used to preheat outdoor air

Phone: 202-508-5500 Fax: 202-508-5222 Toll Free: 1-888-ALL-4-GEO
Internet:http://www.geoexchange.org/ E-mail: info@ghpc.org GHPC #CS-067 8/97

operation, including operating power draws and times for units and independent pumps; air temperatures and flows; liquid temperatures and flows; ground temperatures at coils out to 2 meters; and operating and maintenance costs for individual units and systems.

The closed-loop system includes a variety of ground heat exchanger configurations, incorporated into the design for demonstration purposes at the encouragement of CSC's program manager, Tweedie adds. Two parallel lines of 1¼-inch polyethylene pipe run from the buildings to the ground heat exchanger. Each line forms a series of U-tubes, which pass through boreholes 72 to 289 feet deep and spaced at least 16.4 feet apart. Each line also passes through 650 feet of horizontal trench, where the line is configured into three types of SLINKY heat exchanger configurations and a cylindrical coil heat exchanger. A 1½-horsepower pump circulates 12 gallons of glycol solution per minute through each 14,000-foot loop. Balancing valves maintain equal flow through the parallel loops.

Inside the complex's buildings, 20 water-to-water heat pumps are located with other equipment such as service water heaters in mechanical rooms. The 3-ton heat pumps, with 5-ton heat exchangers and two compressors connected in parallel, provide hot water for the radiant floor space heating and duct heating coils.

In-floor radiant heating was chosen after analysis indicated it would be best for this project because:

- The system uses considerably less energy than conventional systems and so provides environmental advantages.
- The maintenance costs are low.
- The system has no radiators or convection cabinets to be vandalized by residents or to be used as locations for concealing contraband.
- The system could use very-low-temperature water, which could make use of heat recovered from other sources.

Two hot water buffer tanks isolate the high-efficiency, three-stage heat pumps from the interior hot water system and the ground loop. Hot water is also supplied by solar hot water distribution systems incorporated in the design. It can also be supplied by a propane-fueled hot water heater. Although the original design called for the heat pumps to handle 75 percent of the heating requirements, they have been able to handle the entire load.

Refrigeration equipment in the complex's food preparation area is also connected to the ground heat exchanger system. Ventilation air is proved by heat recovery ventilators, with supplemental heating provided by the hot water coils. The gymnasium ventilation is heated with a propane-fired duct heater.

An energy management system monitors and controls the heating and cooling equipment. Only the administrative and reception areas of the complex, about 30 percent of the buildings, are air conditioned; inmate areas are not. (Air conditioning is provided by reversing the GeoExchange system to draw heat from a building and reject it through the ground heat exchanger to the earth.)

Costs and Benefits

Capital costs for the GeoExchange system, including the service hot water heaters (which also provide supplemental heat) and the solar hot water systems, were $247,600, or about $4,130 per ton.

That's about $77,600 more than the estimated cost of an alternative system using high-efficiency boilers and split-system air conditioning.

The benefits of the GeoExchange system come in reduced CO_2 emissions and in lower annual energy costs. Data on the GeoExchange system's energy use collected by the monitoring system were not available when this case study was written.

Based on electric utility and propane bills, the Federally Sentenced Women's Facility used $42,080 worth of energy during its first year. Total energy use had the alternative system been installed is estimated to have run $50,420. Offsetting the energy savings against the incremental costs of the GeoExchange system yields a simple payback period of 9.3 years.

The annual energy use goal for the project was 1,300 megajoules per square meter—about 361 kWh per square meter, or 33 kWh per square foot. That's about one-third the energy used in traditional CSC facilities. The energy use target includes purchased electricity, which is calculated at 3 times the meter reading to account for waste during generation and transmission. Total energy use at the facility during its first year was equal to 36 kWh per square foot, only slightly above the target level, according to the CSC's Brian O'Blenes.

System Performance

Despite some initial operating difficulties, the GeoExchange system at the Federally Sentenced Women's Facility continues to perform very well. There were some installation problems with the system, including errors in the EMS control program and the radiant floor valves. Two compressors and a starting capacitor also had to be replaced. "Other than that, we've had no complaints from our operations and maintenance people," O'Blenes says.

A preventive maintenance program is now in place. It includes weekly walks through the mechanical rooms in the various buildings, a visual inspection of the ground loop, where possible, and regular filter replacement.

Alternatives Considered

Several alternative heating systems were considered during the facility's design phase. These included an oil-fired boiler, electric heat, and a cogeneration system, according to Tweedie. Although O'Blenes' first choice would have been cogeneration with district heating, the facility is too big and the budget was too small to permit that. The decision to go with a closed-loop GeoExchange system was made for a several reasons, including:

- It would allow for the transfer of low-grade heat around the site.
- Air conditioning could be provided by passive cooling with water pumped directly from the loop.
- The low water temperatures used by the radiant heating would maximize the efficiency of the water-to-water heat pumps.
- The loop water could be used to cool compressors for a walk-in cooler and freezer, thus transferring heat to the ground loop system and increasing heat pump efficiency.
- The performance of added solar heating could be maximized by producing low-grade hot water during the winter, adding this to the ground loop and in turn increasing heat pump efficiency.

Outlook for GeoExchange

The Corrections Service, Canada is using GeoExchange in other facilities, including a 1,500-square meter combination parole office and half-way house in St. John, New Brunswick. The system uses five 5-ton units and is already in operation.

A renovation of a piggery on a prison farm in Dorchester, New Brunswick recently began. GeoExchange will be used to heat the farrowing operation and weaning areas. The farm produces about 7,000 pigs per year, O'Blenes says. The facility will use a new design that incorporates domestic hot water, heat pumps, and radiant floor heat all in one unit, according to O'Blenes.

For his part, mechanical designer Tweedie also sees a bright future for GeoExchange. And with one major project under his belt, Tweedie says, "I'd like to have the opportunity to apply the technology elsewhere, in other buildings."

He may get his chance on a his next home. Tweedie would like to build a new home and use GeoExchange to heat and cool it. "I think it's definitely a reliable, proven technology," he says. "If we're ever to reduce our dependence on fossil fuels a bit, it's a technology that needs to be looked at in the future."

Project Participants

Building Owner Representative:
Brian O'Blenes
Correction Services Canada—Atlantic Region
(506) 851-6292

Building Operator:
Mark Murdock
Nova Institution, Truro, Nova Scotia
(902) 420-7966

Mechanical Designer:
Stephen Tweedie
Enerplan Consultants, Ltd.
Moncton, New Brunswick
(506) 858-1300

Mechanical Contractor:
Graham Baxter
G.C. Baxter Plumbing & Heating, Ltd.
Cambridge, Nova Scotia
(902) 639-2433

Heat Pump Supplier:
Glen Kaye
Maritime Geothermal
Petitcodiac, New Brunswick
(506) 756-8135

. Courtesy Caneta Research, Inc.