Restoration Services Centre Facility

CASE STUDY

Geoexchange Series

SITE PROFILE

Building owner	Toronto and Region Conservation Authority
Building location	Vaughan, ON
Building type and use	Two-storey administrative building and garage
Net floor area (ft^2)	12,000
Ground loop	Each heat pump has its own 7-foot deep slinky-style horizontal loop
Number of GSHPs	3
GSHP manufacturer and model	Waterfurnace EW060
Total rated heating capacity (tons)	15.2
Total rated cooling capacity (tons)	15.3
Manufacturer rated coeff. of performance (COP)	3.0
Manufacturer rated energy efficiency ratio (EER)	13.5
Distribution system	Heat pump charges buffer tank used for radiant in-floor heating/cooling and forced-air cooling
Dominant use of system	Heating
Year installed	2007

ABOUT THE SITE

The Restoration Services Centre (RSC) facility in the City of Vaughan was constructed in 2007 for the Toronto and Region Conservation Authority's (TRCA) resource management and environmental restoration projects while also acting as a showcase for sustainable building design. It was one of the first buildings in Ontario to achieve LEED® Platinum Certification for new construction by incorporating a number of advanced sustainable design features. These include: rainwater harvesting, composting toilets, recycled building materials, an earth tube, heat recovery ventilators, photovoltaics, high levels of natural daylighting and a geoexchange system, among other attributes.

RATIONALE AND PLANNING

The Restoration Services Centre was constructed to LEED® standards which showcases TRCA's commitment to sustainability and environmental leadership. The geoexchange system was part of the original facility design leading to a LEED® Platinum Certification. Geoexchange systems are one of the most clean and energy efficient space conditioning systems available and as such, contribute a large number of points to the Energy and Atmosphere component of the LEED® rating system. The system was also cost effective, with a reported expected payback of approximately 10 years.

Figure 1. Three water-to-water heat pumps in the basement mechanical room of the Resotration Services Centre facility.

GEOEXCHANGE SYSTEM DESIGN

The Restoration Services Centre is a 12,000 ft^2 two-storey building that includes both office space and a garage. The geoexchange system is composed of three 5-ton water-to-water heat pumps, each having its own slinky-style horizontal ground loop. The heat pumps operate in parallel to charge a buffer tank that provides heated or chilled water used for radiant in-floor heating and forced-air cooling. The radiant system also provides supplemental cooling under certain conditions. The system is controlled by a building automation system (BAS). The garage is not connected to the geoexchange system and is heated using natural gas radiant tube heaters. This area is maintained at 12°C since the doors are opened frequently.

PROJECT IMPLEMENTATION

The unfamiliarity of the LEED® certification program warranted a prequalification meeting to be held with all potential bidders. Nearly all of the 52 vendors that attended the meeting submitted a proposal. Proposals were prequalified using a comprehensive ranking matrix developed by a team of architects. Eight companies were invited to bid on the project and one was selected to be the primary contract holder for the design-build contract. The primary contractor was responsible for procuring all necessary subcontracts. Management was highly satisfied with the work of both the architectural and mechanical teams.

MONITORING

Performance monitoring equipment was not implemented during the initial installation of the system. Later, in 2013, a monitoring program was developed by the TRCA's Sustainable Technology Evaluation Program (STEP). The monitoring program included ground loop side entering source temperature (EST), leaving source temperature (LST), and flow rate, as well as the power consumption of the units. Data were collected using an Onset Hobo data logger.

PERFORMANCE

System performance during a 3 month monitoring period is presented in Table 1. The cooling mode Energy Efficiency Ratios (EERs) and heat mode Coefficients of Performance (COPs) are calculated in two different ways, either including or not including the electricity consumption of the circulator pumps. When the circulator pumps were not included, the cooling mode EER was between 11.4 and 14.1 while the heating mode COP was

Horizontal ground loops are often the cost effective option in situations where there is ample space available. There are different types of horizontal ground loops including two-pipe, four-pipe, six-pipe and slinky-style designs.

Table 1. Geoexchange system performance results for the Restoration Services Centre facility.

Month	% Time On In Cooling Mode	Avg. EST [°C]	Avg. EST-LST [°C]	Heat Removed [kWh]	Heat Delivered [kWh]	Cooling EER (comp. & ground circ.)	Cooling EER (comp. only)	Heating COP (comp. & ground circ.)	Heating COP (comp. only)
July	11%	14	3.7	720±120	-	11.4±1.9	14.1±1.9	-	-
Aug	9%	16	3.7	610±100	-	10.5±1.7	12.7±1.7	-	-
Sept	4%	17	3.8	280±50	390±40	9.5±1.7	11.4±1.7	3.5±0.4	3.9±0.4

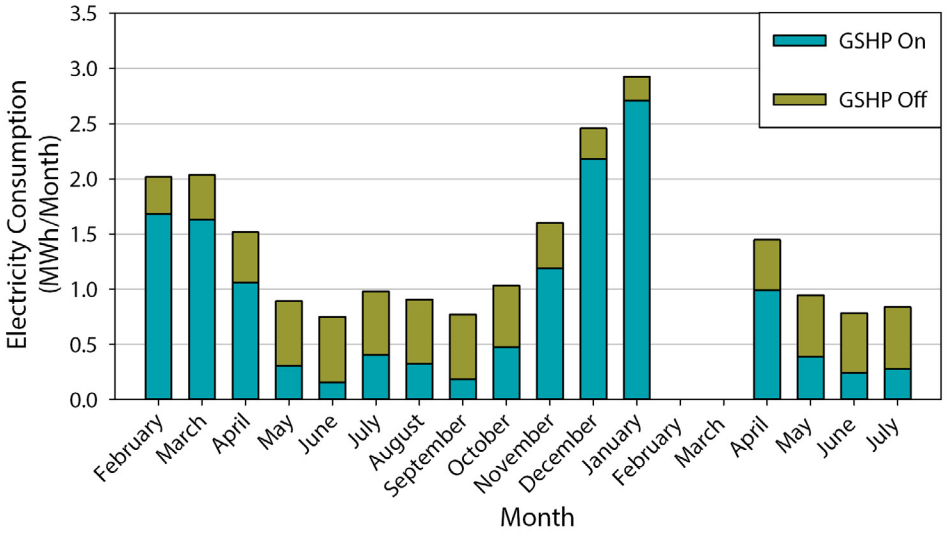

Figure 2. Electricity consumed by the system when the heat pump is operating (includes both the circulator pumps and the heat pump), and when it is not. The latter is electricity that is consumed unnecessarily by the un-interlocked circulator pumps. Note that the electricity consumed when the heat pump was off was not included in the COP calculations for this system.

3.9. However, these numbers should not be directly compared to the manufacturer ratings because of different experimental constraints. Based on heating design-day performance the system appears well-sized for the load without being prohibitively oversized.

During the monitoring period, it was discovered that the distribution and ground loop circulator pumps were left to run at all times. This resulted in a cooling mode COP degradation of as much as 80% and a 50% increase in the annual electricity consumption. The electricity consumed unnecessarily by the un-interlocked circulator pumps is illustrated in Figure 2.

OPERATION AND MAINTENANCE

Nearly all mechanical systems within the building are under a maintenance contract with the mechanical contractor who installed the systems. Maintenance of the geoexchange system was reported to require no additional effort to maintaining a conventional HVAC system.

COSTS

The building was constructed in 2007 at a cost of approximately 2.9 million dollars. The capital cost premium to construct a LEED® Platinum facility was reported to be less than 10%.

SUCCESSES

The Restoration Services Centre facility was one of the first building in Ontario to be designated LEED® Platinum for New Construction, scoring 56 points at the time of certification. Management has stated that the geoexchange system is "practical, functional, and cost-effective" and would strongly consider installing geoexchange in other buildings. The facility manager reports that the geoexchange system and the associated distribution systems are quiet and provide evenly distributed heating and cooling. The Restoration Services Centre facility is a model for sustainable design in a practical context and contributes to TRCA's vision of a Living City®, "a new kind of community where human settlement can flourish forever as part of nature's beauty and diversity."

LESSONS LEARNED

Circulator pumps that are not interlocked to the heat pump can severely limit system cost-performance. In this case, the circulator pumps that are not interlocked add an additional 50% to the annual energy consumption of the system. The cost of fixing this issue will likely be recouped within only a year of operation.

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