Greater Toronto Airports Authority

CASE STUDY

Geoexchange Series

©Andrew H. Cline\ www.airportwatchcanada.com\Airport Authority Firehall #2 North Hall, Pearson International Airport

SITE PROFILE

Building owner	Greater Toronto Airports Authority
Building location	Mississauga, ON
Building type and use	One-storey fire hall used for housing, adminstrative and vehicle storage purposes
Net floor area (ft^2)	10,000 to 15,000 (estimated)
System type	Vertical closed loop
Ground loop	8 vertical boreholes drilled to a depth of 400 ft
Number of GSHPs	4 (each rated for 50.5 MBtu/hr heating and cooling). One heat pump is connected to a desuperheater that supplies heat to the domestic hot water (DHW) loop.
GSHP manufacturer and model	Johnson Controls (water-to-water)
Total rated heating capacity (tons)	16.8
Total rated cooling capacity (tons)	16.8
Distribution system	Forced-air
Backup system	One 645 MBtu/hr Weil MacLean hot water boiler that was used pre-retrofit
Year installed	2012

ABOUT THE SITE

The Greater Toronto Airports Authority (GTAA) operates and manages Toronto Pearson Airport, Canada's largest and most frequented airport. The airport moved 31.9 million travelers in 2010 and averages 1,175 flights per day (Toronto Pearson, 2014). The North Fire Hall is located at 6658 Vanguard Drive in Toronto and houses the firefighters working for Toronto Pearson.

RATIONALE AND PLANNING

The GTAA was the first airport in North America to achieve ISO 14001 certification for environmental management. The organization chose to implement a clean energy project at the airport in order to further its environmental mandate. Management commissioned a feasibility study to evaluate several clean energy technologies and geoexchange was found to be the most viable option. The geoexchange project was implemented as a trial in order to assess potential for broader implementation in other airport facilities.

The North Fire hall was selected for the geoexchange system because it had an aging HVAC system and the building is small and isolated, making it an ideal test site. In addition, the use for the building and the surrounding land is unlikely to change for the long term, ensuring that the borefield will not hinder future development.

GEOEXCHANGE SYSTEM DESIGN

The retrofit geoexchange system heats and cools the housing and office areas of the North Fire Hall, replacing two 645 MBtu/hr Weil MacLean hot water boilers (one of which was kept as a back-up for the geoexchange system) and a 30 ton air-cooled McQuay water chiller. The geoexchange system is a closed loop vertical system containing 8 boreholes and 4 heat pumps. The garage is served by gas-fired low intensity infrared tube heaters. This area also contains a gas-fired domestic hot water heater (DHW) used for laundry and fire vehicle washing. Post-retrofit, all DHW systems remain in use and one of the four heat pumps is connected to a desuperheater that preheats the domestic hot water supply.

PROJECT IMPLEMENTATION

The geoexchange retrofit was implemented through a design-build contract. The primary contractor was responsible for coordination of all subcontractors, reducing the time spent by the GTAA on project management. A total of four companies played a major role in project implementation. One firm conducted the initial feasibility study and guided the selection of an appropriate facility for the installation to install the geoexchange system. A second firm (the primary contractor) designed the system, and a third provided installation and commissioning services. A specialized energy engineering company was also procured to verify the commissioning, install metering, and monitor system performance for one year.

MONITORING

Since this is a trial geoexchange system to potentially be used in other buildings on the property, an external consultant was contracted to perform in-depth performance monitoring for approximately one year following the retrofit. To track system performance, data loggers were installed on all energy consuming appliances used for heating and cooling and collected data were normalized against local weather conditions. Since no data were available regarding pre-retrofit energy use, an estimate was made based on the theoretical energy use of a typical 10 year old natural gas boiler and chiller systems.*

In cooling mode, a conventional geoexchange system rejects heat energy from the building to the ground. However, a potentially more efficient mode of operation is possible by using a desuperheater. It is a secondary heat exchange coil in the heat pump's refrigeration cycle that is capable of using some of the rejected heat energy to heat water for domestic hot water applications.

Figure 1. Four geothermal heat pumps in the North Fire Hall.

PERFORMANCE

Table 1 presents the seasonal and annual coefficients of performance (COPs) calculated for the GTAA geoexchange system. The COP reported includes the power consumption of the heat pumps but not the circulator pumps. The COPs during the heating and cooling season were 2.57 and 4.38 respectively, reaching an Energy Efficiency Ratio (EER) of 14.9. Model numbers of the heat pumps were unavailable to compare COPs to the manufacturer ratings. The cooling COP is reasonable while the heating COP is lower than expected. There were several possible contributing factors to the low heating mode COP:

1. The original air handler coils, designed to be used for the boiler, were not replaced and were insufficient when used with the lower temperature water supplied by the heat pumps.
2. There appeared to be cooling mode operation during the heating season, perhaps due to a controls issue, and this may have contributed to degraded heating mode performance.
3. Circulator pumps are insufficiently interlocked to the heat pumps and are operating the majority of the time whether there is a heating demand or not.**

*A chiller COP of 2.5 and a boiler efficiency of 70% were assumed. Details regarding the estimation method can be found in the following report: AMEC Environment & Infrastructure. 2013. Greater Toronto Airports Authority: North Fire Hall Ground Source Heat Pump Performance Monitoring, Final Report. AMEC Project # TR1713018.

**However, if the circulator pump power consumption is not included in the COP calculation, then this would not affect the COP.

It is estimated that geoexchange system saved 3,015 kWh annually in cooling mode. In heating mode, the system reduced natural gas consumption by 4,798 m^3/ year but introduced a new electrical load of 36,440 kWh/ year.

Table 1. Performance analysis.

Season	Start of Period	End of Period	COP
Heating	October 1, 2012	March 21, 2013	2.57
Cooling	May 22, 2012	September 5, 2012	4.38

OPERATION AND MAINTENANCE

The facility manager reports that operation and maintenance of the geoexchange system requires more effort due to the insufficiently sized fan coils in heating mode. If the geoexchange system had been properly integrated with the existing distribution system, the maintainance requirements would be less than or equal to a conventional HVAC system. Aside from this issue, the cost to maintain the geoexchange system was reported to be lower than the cost to maintain a boiler and rooftop chiller system.

SUCCESSES

Despite the challenges experienced in this retrofit project, GTAA management has gained confidence in geoexchange technology and would consider implementing it in other suitable airport facilities. Toronto Pearson has an extensive land base capable of supporting large-scale geoexchange projects.

LESSONS LEARNED

Salvaging existing components may help to reduce system costs but consideration must be given to whether these components can be appropriately integrated for the operating parameters (ie. temperatures, flows, etc.) of a geoexchange system.

Pre-retrofit baseline energy consumption data was not collected. This meant that the post-retrofit data needed to be compared less-confidently against simulated energy use. Ideally, pre-retrofit data is collected so as to perform a proper comparison.

REFERENCES

AMEC Environment & Infrastructure (2013) Greater Toronto Airports Authority: North Fire Hall Ground Source Heat Pump Performance Monitoring, Final Report. AMEC Project # TR1713018

Toronto Pearson(2014) Airport Facts. http://www.torontopearson.com/en/Airport_Facts/#. Accessed October 31, 2014

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