Region of Peel and Peel Living

CASE STUDY

SITE PROFILE

Building owner	Region of Peel in partnership with Peel Living
Building location	Brampton, ON
Building type and use	Residential group homes
Net floor area (ft^2)[1]	1,750 (House A) 5,360 (House B)
Ground loop	DX ground loop consisting of 4 vertical boreholes at 100 ft deep
Number of GSHPs	1
GSHP manufacturer and model	EarthLiked SCW-048-1B
Total rated heating capacity (tons)	4.2
Total rated cooling capacity (tons)	4.0
Rated coeff. of performance (COP)	3.5
Rated energy efficiency ratio (EER)	15.0
Distribution system	Heat pump charges buffer tank which supplies hot/chilled water to multi-zone air handling system
Backup system	Hot water heater (gas in House A, electric in House B)
Dominant use of system	Heating
Year installed	2009

[1] Net floor area includes basement

ABOUT THE SITE

The Region of Peel is the second largest municipality in Ontario, serving more than 1.3 million people in Brampton, Mississauga and Caledon. Administered by the Region of Peel, Peel Living is a non-profit housing company that has provided housing in 70 sites for 7,100 residents in the Region. Peel Living is recognized as the third largest social housing provider in Ontario and a leader in innovative housing projects. The Peel Living geoexchange sites examined in this case study are retrofit systems installed in residential social housing buildings. A holistic design approach was used for each retrofit project, which included: (i) installation of a geoexchange system, (ii) upgrades to distribution and ventilation systems, and (iii) installation of solar hot water heating. Limited work was done to improve the building envelope and other building features so that the project findings will be replicable in other town homes where extensive renovations are not feasible. The distribution system in each home was upgraded from a single zone system to multi-zone systems to reduce hot and cold-spotting.

RATIONALE AND PLANNING

As part of its 2006 Energy Management Plan, the Region of Peel in partnership with Peel Living undertook several renewable energy and energy efficiency demonstration projects in order to assess the suitability of the technologies for broader implementation in municipal facilities. This initiative included three pilot geoexchange projects (two of which are reported on here) located in three municipally-owned social housing town homes. The regular occurrence of hot and cold spots had been an ongoing problem in the homes and the Region/ Peel Living believed that the installation of a geoexchange system and upgrades to each home's distribution system would improve the thermal comfort of residents.

The geoexchange projects were initiated in 2006. It took more than two years to build support for the projects due to the large number of stakeholders involved and the fact that this was the first initiative of its kind for both Peel Living and the Region of Peel. Since geoexchange was relatively unfamiliar, the Peel Living went to great lengths to engage and educate union supervisors, property managers, and town home staff. In addition to several rounds of meetings and other communications, staff were taken on bus tours of installed geoexchange systems in the local area to learn about the technology.

GEOEXCHANGE SYSTEM DESIGN

The three vertical closed loop geoexchange systems were installed between December 2009 and January 2010. All systems are direct expansion (DX), meaning that a refrigerant rather than a glycol solution is circulated through the ground loop. Each ground loop was designed to be slightly oversized in order to have excess capacity in the event that the loads were greater than anticipated. Each geoexchange system is backed up by a natural gas or electric hot water heater capable of providing 100% of each home's heating load. The systems charge a buffer tank which is then used to heat and cool the building using zoned air handlers.

Figure 1. DX ground-source heat pump in basement mechanical room of House A.

PROJECT IMPLEMENTATION

The procurement of contractors and consultants to perform the work proved to be a challenge initially. At the outset, there was an attempted to combine the procurement of the geoexchange, energy efficiency, and solar water heating components of the retrofits. The first round of procurement failed due to the inability to find a vendor offering integrated energy management solutions at the home level. In the second round, each component of the retrofit was procured separately. Demand for geoexchange was very high in 2008 and procurement failed a second time because most vendors were unable to take on additional contracts. Peel Living ultimately procured a vendor for a design-build contract and was highly satisfied with the service provided by the project team.

Vertical ground loops may be conventional or direct-exchange (DX). While a conventional ground loop might contain a heat transfer fluid such as glycol, a DX ground loop contains refrigerant and is directly connected to the refrigerant circuit of the heat pump. DX systems may have potential gains in efficiency owing to the fact that they do not require a ground-side circulator pump and heat exchanger.

MONITORING

Energy monitoring was accomplished remotely on two of the installations (House A & B), using an Obvious Aquisuite A8812 data acquisition system with an integrated GSM modem. The power consumption of the HVAC system, including the back-up system, geoexchange system and distribution system, was monitored alongside the heat energy delivered by the systems. A Badger Series 380 Btu meter recorded the entering and leaving load-side temperatures and flow rate on a one minute timescale. Monitoring data was analyzed by the Toronto and Region Conservation Authority's (TRCA) Sustainable Technology Evaluation Program (STEP) for the 2013 year.

PERFORMANCE

Based on the design day heating performance both systems are likely to be well-sized for their heating and cooling loads without being prohibitively oversized. In both buildings, the heating load was larger than the cooling load but, because of the heat energy added by the compressor, the ground had an annual net heat gain of the scale of a quarter to a third of the total annual heating load. Imbalances such as this may result in ground temperature changes

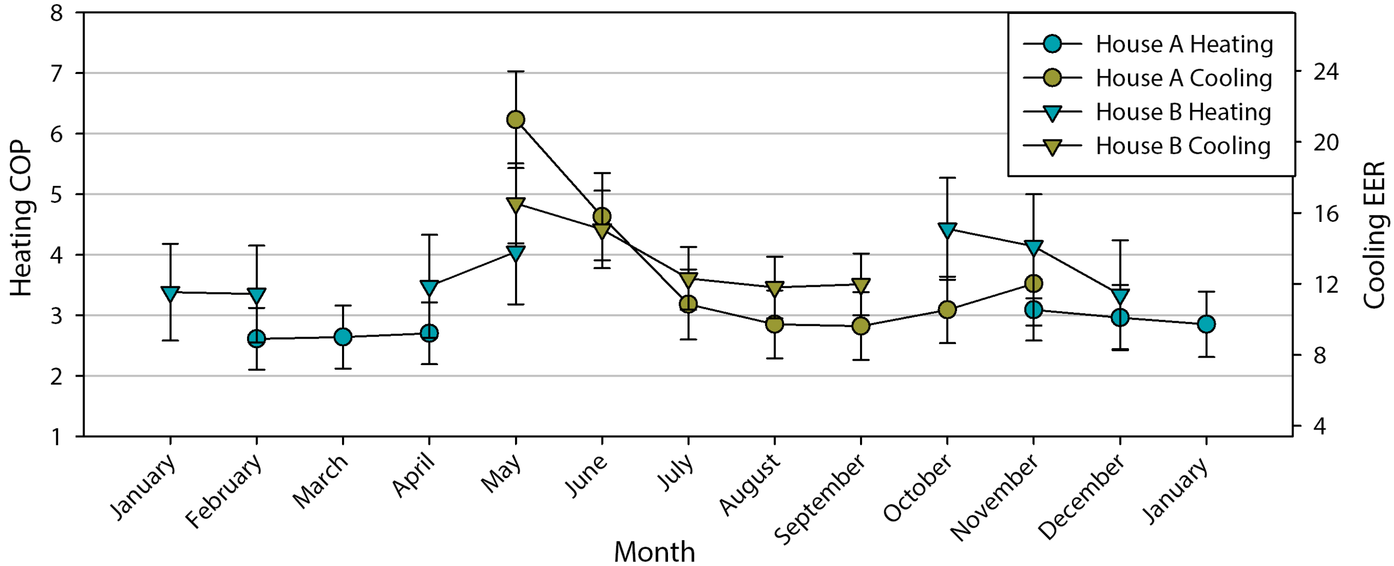

Figure 2. The monthly COP and EER from Peel House A and B.

that could degrade performance over time if not accounted for in the system design.

The monthly heating Coefficients of Performance (COP) and cooling Energy Efficiency Ratio (EER) for both houses are plotted in Figure 2. The annual heating COP and cooling EER for House A was 2.8±0.5 and 10.9±2 while those for House B were 3.5±0.8 and 13.0±2. House B appears to be performing as expected but House A is underperforming. One contributing factor to this underperformance is likely related to the fact that House A is operating with much lower cycle times. For example, when the House A geoexchange system turns on in heating mode, it will not stay on for longer than 10 minutes while the House B system will be on typically for between 20 and 30 minutes. This issue was discussed with the HVAC contactor responsible for system maintenance and he adjusted the aquastat settings on the buffer tank in an attempt to promote a longer cycle time and hopefully improve system performance.

OPERATION AND MAINTENANCE

During the commissioning process, it was discovered that the system filters in one home were becoming clogged more quickly than expected. The cause of this issue was found to be the construction of a home on a neighbouring lot. Stone cutting activities were producing a fine dust that was being drawn into the home's ventilation system. This problem was resolved by changing the filters every two months instead of every six months until the construction was completed. This example illustrates the importance of the commissioning processes and regular maintenance for identifying and resolving issues that can adversely affect system performance. For this reason, all of the sites are under a maintenance contract with a local HVAC contractor for routine system maintenance.

COSTS

The Region placed a cap on the project budget in order to mitigate financial risk. The project received financial support from the Municipal Eco Challenge Fund (MECF), which covered approximately 25% of the total cost.

GREENHOUSE GAS EMISSIONS ANALYSIS

GHG emissions reductions were calculated for the geoexchange retrofit versus the pre-retrofit base case heating system, specifically, a natural gas hot water heater storage tank in House A and an electric hot water heater storage tank in House B. Base case efficiencies were assumed to be 80% for House A and 95% in House B, which are higher than typical values for the rated efficiency (termed the "energy factor") of hot water heater storage tanks. This is to achieve a fairer comparison between the ratings of the tanks, that include standby losses, and the geoexchange system COPs, that do not include standby losses. The GHG emissions reduction calculations assume no change between pre- and post-retrofit heating loads. It should be noted that this is an oversimplification since the buildings were upgraded to a zoned distribution system, which would have decreased the post-retrofit heating loads. However, the difference could not be adequately quantified with the limited available data.

In addition, the analysis was further simplified to consider only heating mode operation. It was assumed that: (i) the greenhouse gas emissions resulting from electrical power consumption is 0.11 kg eCO_2/kWh (Environment Canada, 2013); (ii) one cubic meter natural gas contains 0.0373 GJ of energy (Natural Resources Canada, 2014) and (iii) the greenhouse gas emissions resulting from natural gas combustion is 1.891 kg eCO_2 per cubic meter of natural gas (Environment Canada, 2008). It should be noted that the leakage of natural gas during mining or distribution was not considered.

Based on these assumptions, the emissions reductions associated with the geoexchange retrofit were estimated to be 4,300 kg eCO_2 for House A and 1,900 kg eCO_2 for House B. For context, an average car in Canada emits approximately 3,360 kg eCO_2 annually (Canadian Geoexchange Coalition, 2010). Therefore, heating House A with a geoexchange system rather than the conventional natural gas technology produces a GHG emissions savings equivalent to taking 1.3 cars off the road annually. The simplifications of the analysis produce highly conservative estimates of GHG savings with the actual savings likely being much better.

SUCCESSES

Occupants of the town homes are very pleased with the results of the geoexchange retrofit and distribution system upgrades. Heat and cooling are more evenly distributed within the homes and hot and cold spot problems have been mitigated. Prior to the retrofit, supplementary heaters had been required in north-facing rooms, which is no longer necessary. Peel Living have found geoexchange to be well suited for a town home structure, and would consider installing geoexchange systems in other social housing units. Management noted that geoexchange would be particularly effective in homes where residents pay their own utilities, as residents have a vested interest in system performance. Geoexchange was also believed to be relevant in a social housing context because of the lower operating costs. Peel Living and Region of Peel consider the project to be a success.

LESSONS LEARNED

It was observed that the House A geoexchange system was underperforming when compared with House B. One potential contributing factor was identified as being the short compressor cycle times experienced by House A. Current design guidelines do not seem to address cycle time but it may have the potential to notably affect system performance and the lifetime of components. It is recommended that cycle time guidelines be established and incorporated into commissioning procedures.

REFERENCES

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