geofease

ProFease Report - Sudbury, ON

About the Project

This building has a size of approximately 60,000 square feet. The report that follows is an estimate of the feasibility of using an "alternative" ground-source heat pump geothermal heat exchanger for meeting the heating and cooling requirements of the building, when compared to a conventional system.

Executive Summary

This report provides an organized comparison of two buildings: (1) a building that includes energy-efficiency measures and a **conventional** heating and cooling system, and (2) the *same* building with energy-efficiency measures and with an **alternative** ground-source heat pump system. The report is designed to enable decision makers to rationally select an appropriate energy-efficient and environmentally friendly HVAC solution for a particular building.

Table I summarizes the comparison results. It includes the cost of installing the HVAC systems in the two different buildings with the selected energy efficiency measures and any estimated incentives that may be available. Table I also provides energy cost comparisons, and the overall economics associated with the two building configurations.

Table I: Financial and Environmental Summary

	Conventional	**Alternative**
Description	Electric / Gas	GSHP
Base System Cost[1]	$1,800,000	$1,800,000
GHX System Cost[2]	---	$264,000
Exhaust Energy Recovery Cost[3]	---	$120,000
Total Cost	**$1,800,000**	**$2,184,000**
INCREMENTAL COST	---	**$384,000**

Heating and Cooling Costs		
Total Heating Cost[5]	$55,251	$8,929
Total Cooling Cost[6]	$3,205	$1,527
Total Heating and Cooling Cost	$58,456	$10,456
ANNUAL COST SAVINGS	---	**$48,000**

Financial Analysis[7]		
Return on Investment [20 years]	---	**15.2%**
Net Present Value [20 years]	---	**$510,427**
Internal Rate of Return [20 years]	---	**12.8%**
Simple Payback	---	**8.0 years**

Equipment Efficiencies		
Cooling Efficiency - EER	14.7	34.2
Heating Efficiency - COP	0.6	4.0
Peak Load and Installed Capacity		
Max Peak Load	104 tons	66 tons
Installed Capacity (120% - 140%)	**125 - 146 tons**	**79 - 92 tons**

Purchased Energy Required		
Heating	1,974 MMBtu	197 MMBtu
Cooling	70 MMBtu	34 MMBtu
Total Heating and Cooling	2,045 MMBtu	230 MMBtu
REDUCTION IN ENERGY USAGE	---	**1,815 MMBtu**
Percent Reduction in Energy Use	---	**89%**

CO_2 Reductions[8]		
CO_2 Emissions Produced	**124 tons**	**30 tons**
Percent CO_2 Emissions Reduction	---	**75%**

NOTE: We base the economics of this project on a ***pre-calculated hourly energy model****, similar in area and function to the proposed building simulated with Sudbury, ON, weather data. We then base our size and cost estimates of the GHX on the same energy model. By working with the architectural and engineering design teams, the designers may integrate any additional energy efficiency measures to further optimize the design and performance of a GSHP system for this building. This will require an accurate hourly energy model of the specific building and site.*

Estimated Energy Consumption

Energy consumption in the facility will vary based on building construction and selected mechanical systems. Changing insulation values, type of glass, lighting, ventilation strategy, etc. will change heating and cooling energy consumption and peak heating and cooling loads. This impacts the size and cost of the mechanical system and, to a greater extent, the size and cost of the ground heat exchanger (GHX).

We estimate the energy consumption and peak heating and cooling loads of the proposed facility shown in Figure 1 and Figure 2 by using a similar school building that has been re-calculated using *Sudbury, ON*, weather data and adjusted to match the size of the proposed building.

NOTE: Developing an accurate hourly energy model of the proposed project requires architectural and engineering drawings and specifications along with building occupation information. The building modifications in this report represent some potential changes and their impact on the size and cost of a GHX required to meet the needs of the building. An experienced designer working closely with your architectural and engineering design team may use iterative energy modeling to further optimize the building GSHP system.

The base energy model for the selected building is built to ASHRAE 90.1 standards for the location. If energy efficiency measures are implemented in the proposed building, heating and cooling loads change. This building's efficiency measures include:

- Exhaust air energy recovery

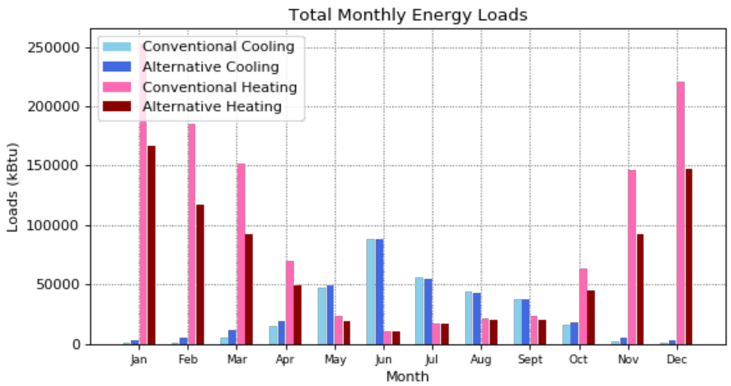

Figure 1: Comparative monthly total heating and cooling energy loads of a building constructed to ASHRAE 90.1 efficiency standards and the same building with the impact of a 70% efficient energy recovery ventilation system.

Adding exhaust air energy recovery reduces energy consumption for both heating and cooling.

- Cooling energy consumption is reduced approximately *-8%*
- Heating energy consumption is reduced approximately *32%*

- Peak cooling load is reduced from 872 kBtu/hr to 793 kBtu/hr, a reduction of approximately *9%*
- Peak heating load is reduced from 1,250 kBtu/hr to 716 kBtu/hr, a reduction of approximately *42%*

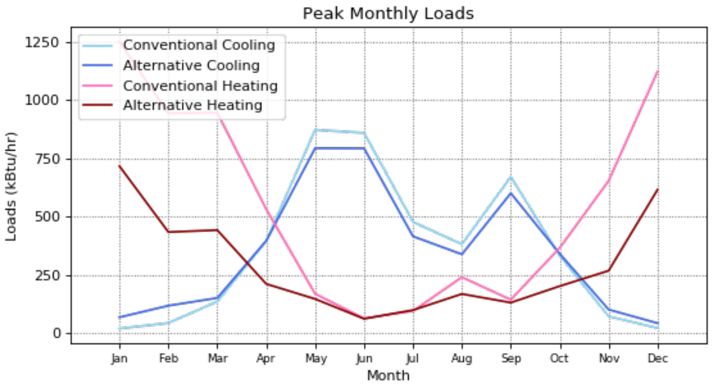

Figure 2: Comparative monthly peak heating and cooling energy loads of a building constructed to ASHRAE 90.1 efficiency standards and the same building with the impact of a 70% efficient energy recovery ventilation system.

Heating and Cooling Equipment Efficiencies

The efficiency of the heating and cooling equipment selected for the conventional and alternative buildings is critical for calculating the energy consumption. In general, heat pump technologies are inherently more efficient than conventional equipment, and this leads to lower energy consumption and operational costs. In addition, any equipment that can be kept indoors is protected from the elements and will require less maintenance and have a longer expected lifetime.

For this comparison, we selected a high-efficiency *ground-source heat pump* (34.2 EER/4.0 COP) for the alternative system, whereas the conventional system has a standard-efficiency cooling unit (14.7 EER) and a standard-efficiency *gas* heating unit (0.6 COP). We see the scale of the efficiency differences in Figure 3. Note that even in the environmentally friendly alternative systems, choosing the highest efficiency hardware can make a sizeable difference in the amount of cost savings over the long term. Typically, the heating efficiency of heat pumps over conventional fuel units is the most pronounced, and that's what can drive the considerable cost savings and the CO_2 reduction.

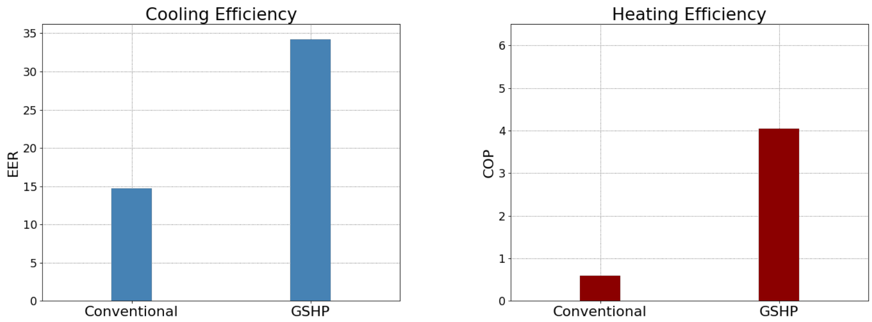

Figure 3: Comparative heating and cooling equipment efficiencies for the conventional vs the alternative GSHP system.

Ground Heat Exchanger (GHX)

Modifying the building and mechanical system design changes the amount of energy rejected to the ground heat exchanger (GHX) when the building is being cooled and the amount of energy extracted from the GHX when the building is being heated. This directly impacts the size and cost of the GHX needed to meet the building energy loads.

The design of the GHX also directly impacts the size and cost of the GHX. The geology, borehole layout and spacing, the grout installed in the borehole and the efficiency of the heat pump equipment connected to the GHX are some of the major factors that affect the size and cost of the system.

Taking some time to review the geology at the site, the land area available for constructing the GHX, and the numerous optimization options for GHX designs can result in significant capital cost savings.

We generated a GHX design that incorporates the energy efficiency measures previously described. The GHX design, based on customized inputs, includes:

- A 16 x 2 grid borehole layout at a depth of 300 ft
- 25 foot spacing between boreholes
- High soil thermal conductivity
- High grout thermal conductivity
- High-efficiency heat pump equipment

The land area required for the optimized GHX design would be approximately *17,775 square feet.*

The GHX for the 60,000 square foot school building located in or near Sudbury, ON is based on a 20-year temperature prediction. The maximum and minimum temperatures the GHX can be expected to operate at are 60.1°F in summer and 32.0°F in winter. Table II presents the GHX-related results summarized in a more organized format.

Table II: GHX Summary

Description	Results
Soil Thermal Conductivity [Btu/(h·ft·°F)]	High
Total Borehole Length	**9,600 ft**
Borehole Length	300 ft
Number of Boreholes	32
Grid Pattern	16 x 2
Spacing between Boreholes	25 ft
Approximate Land Area Required	17,775 ft^2
Grout Thermal Conductivity [Btu/(h·ft·°F)]	High
Maximum Expected Temperature	**60.1 °F**
Minimum Expected Temperature	**32.0 °F**

GSHP Project Environmental Impact

A GSHP system eliminates or reduces the amount of fossil fuel used for heating and generating hot water. GSHP systems reject heat more efficiently than air-cooled condenser or evaporative cooling tower systems, thereby reducing onsite greenhouse gas emissions. Figure 4 compares the predicted CO_2 emissions from the proposed building built with gas heating and conventional cooling utilizing the user-selected energy efficiency measures, versus the GSHP alternative.

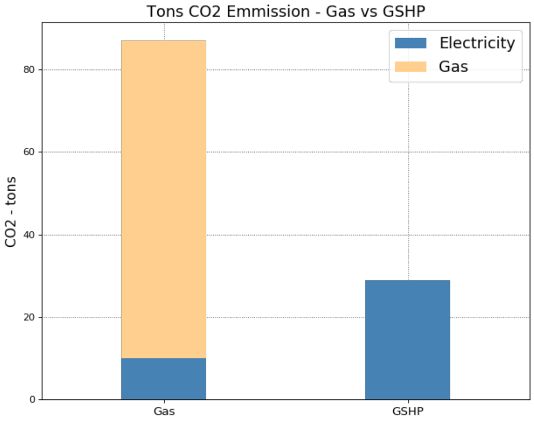

Figure 4: Compares CO_2 emissions from the proposed school building with energy efficiency measures that uses gas heating and conventional cooling, versus the same school building with the same energy efficiency measures but heated and cooled using a GSHP system.

Conclusion

This concludes the feasibility study of ProFease Report in Sudbury, ON.

[1] $30/square foot of building
[2] $27.50/foot of bore
[3] $2.00/square foot of building
[5] $0.800/Therm fuel cost
[6] $0.155/kWh electricity cost
[7] Investment Term: 20 years, Discount Rate: 2.5%, Electricity Inflation Rate: 2.0%, Fuel Inflation Rate: 2.0%
[8] 0.880 lbs/kWh, taken from https://www.eia.gov (US) or https://www.cer-rec.gc.ca/ (Canada)