FACT SHEET

Assessing the Feasibility of a Geoexchange System for your Agricultural or Agri-Food Operation

Geoexchange systems are an increasingly common technology used to provide efficient, renewable heating and cooling for buildings and industrial processes. Geoexchange systems use a ground heat exchanger, one or more ground source heat pumps, and an interior distribution system to move heat to and from the ground and a building.

Several factors affect the technical feasibility and financial viability of geoexchange systems in agricultural and agri-food operations. These include:

- base-case fuel costs;
- available ground heat exchanger options;
- heating and cooling load duration; and
- existing interior distribution systems.

This fact sheet discusses these factors, and provides guidance for how to assess whether geoexchange heating or cooling might benefit your agricultural or agri-food operation.

This fact sheet is based on results from the *Geoexchange Feasibility in Agricultural and Agri-food Operations Benchmarking Study*. This study is available at ***http://www.agrifoodbc.ca/renewable energy/*** **and** includes five individual feasibility studies and site assessments of Agricultural operations. Funding for this project was provided by *Growing Forward*, a federal-provincial-territorial initiative.

Characteristics of Profitable Geoexchange Systems

Base-case Fuel Costs

Geoexchange systems usually involve switching a large portion of annual energy costs away from fossil fuels to electricity that drives the heat pump. Therefore, the cost of fossil fuels and electricity has a strong effect on project profitability. Higher cost base-case fuels, such as propane, are more likely to lead to profitable geoexchange systems, while lower cost base-case fuels, such as natural gas, are less likely to lead to profitable geoexchange systems.[1] Potential energy cost savings can be estimated using the forms on page 4 of this fact sheet.

[1] See Appendix B of the *Geoexchange Feasibility in Agricultural and Agri-food Operations Benchmarking Study* for the range of energy prices in affect at the time of the study.

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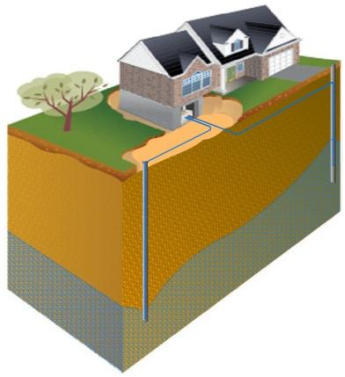
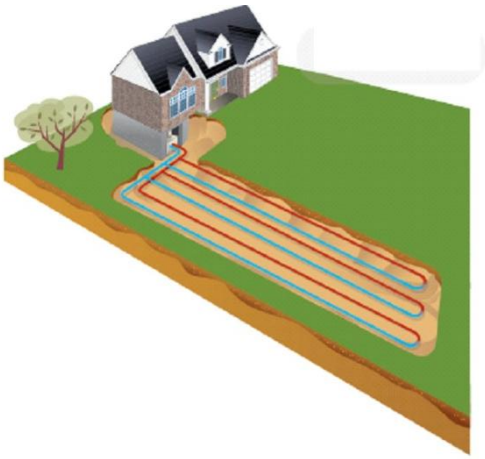
Available Ground Heat Exchanger Options

Because of the tectonic and glacial history in B.C., ground conditions are more variable than virtually anywhere else on Earth. This is important because the geological attributes of a location can significantly affect the costs and performance of the ground heat exchanger portion of a geoexchange system. For example, while one site may have conditions that can accommodate a low-cost, high performance ground heat exchanger option, a nearby site may have conditions with limited opportunities that can only accommodate a high-cost, low performance ground heat exchanger. As a result, the cost for the same geoexchange capacity can vary by more than an order of magnitude from one site to another, highlighting the key role site specific characteristics can play in project economics.



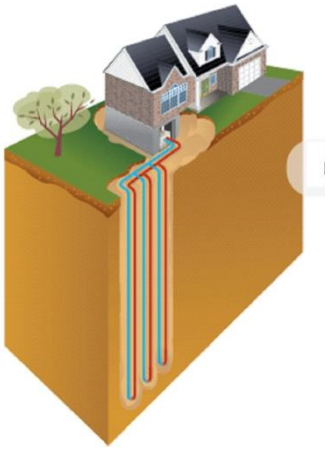
Groundwater Open-loop Ground Heat Exchangers:

In certain rare settings with highly productive aquifers, very high ground heat exchange capacity can be achieved at a relatively low cost. Where these conditions exist, geoexchange systems can often be profitable over a broad range of base-case fuel costs, heating and cooling requirements, and existing distribution systems. In some circumstances an owner may already have a high capacity water well in place that could be used to supply a geoexchange system. These conditions can be very profitable because a significant portion of the installation cost is eliminated. It warrants noting that care must be taken for this type of system to ensure the water quality is compatible for heat exchange and the production of sufficient groundwater is sustainable over the long-term.



Horizontal Closed-Loop Ground Heat Exchangers:

Agricultural and agri-food operations often have large open land areas suitable for a horizontal ground heat exchanger. The ground conditions in the upper 4ft to 10ft can significantly influence construction costs for this option. In settings with fine-grained soils free of stones, very inexpensive horizontal ground heat exchangers can often be installed with little surface disturbance using a chain trencher. Trenching with an excavator is also common, with installation costs varying depending on trench wall stability, presence of cobbles and boulders, or other conditions that affect the excavator time required. In some settings with unconsolidated loose soils, the most cost effective approach is to strip a larger single excavation with a dozer and install a mat of piping rather than excavate multiple trenches.



Vertical Closed-loop Ground Heat Exchangers:

In some cases, a vertically-bored ground heat exchanger may be the only option available. In these cases it is important to evaluate ground conditions carefully. In B.C.’s diverse geological settings, the costs associated with installing a vertical borehole ground heat exchanger can vary significantly and is often the determining factor in a project’s profitability. Installed cost is dependent on the ease of drilling and installing the heat exchange tubing, and the thermal exchange properties of the soil/bedrock that is encountered. Good conditions occur where straightforward drilling techniques can be used and soils

with good thermal properties, such as shallow bedrock, allow shorter total borehole length. Poor conditions occur where the bedrock occurs at an awkward depth that requires different drilling techniques to complete shallow and deeper segments of each borehole, or where drilling is otherwise challenging or unusually expensive (e.g. highly fractured bedrock, the presence of large boulders in unconsolidated soils, etc.). Low thermal conductivity soils such as dry sands and gravels can require considerably longer total bore length, though the longer bore length required in these settings may be offset by the suitability of less costly drilling methods.

GeoExchange BC, a non-profit industry association, has developed professional guidelines to address the important step of evaluating potential ground heat exchanger opportunities (***Professional Guidelines for Geoexchange Systems in British Columbia - Part 1 Assessing Site Suitability and Ground Coupling Options; Geoexchange BC, 2007***).

Heating and Cooling Load Duration

A common feature of profitable geoexchange systems is a long duration heating or cooling load. This occurs because capital equipment can only generate a return on investment when operating. Short duration, high intensity loads are the least profitable because the necessary high capacity equipment only operates for a limited number of hours in a typical year, and therefore cannot produce enough savings to overcome high installation costs.

Facilities with longer duration heating requirements, including relatively continuous process heating requirements and/or unique heating loads that extend into the summer, are the most likely to be profitable.

Because geoexchange systems can provide both heating and cooling, long run times can also occur for facilities that require both winter heating and summer cooling. Facilities that have concurrent heating and cooling loads can often recover the heat being rejected in the cooling process and use it to offset heating requirements. Heat recovery from concurrent cooling loads is often very profitable.

Interior Distribution Systems

In retrofit applications, the existing heating and cooling distribution system may or may not be easily adapted to a new geoexchange system. Extra costs to modify existing distribution systems, or to install new distribution systems can lower overall project profitability.

Additional costs are often required to modify existing heating and cooling systems that consist of many small distributed unit heaters or roof top units. Geoexchange systems are often most easily adapted to existing hot water heating distribution systems and central boiler or furnace systems. It is important to recognize that most geoexchange systems cannot generate the high temperatures that conventional boilers can. Lower temperature systems like radiant floors are often ideal candidates for direct connection to a geoexchange system with no additional distribution system costs.

New construction often provides more flexibility than retrofit situations for designing a distribution system with geoexchange in mind.

Estimating Potential Savings

A quick estimate of the potential energy costs savings that could be achieved with a geoexchange system can be calculated with the formulas below. These calculations are based on a number of simplifying assumptions, but will provide a rough estimate for owners to determine if the potential savings from a geoexchange system warrant further evaluation.

Potential Geoexchange Savings vs. Natural Gas

Hybrid System with geoexchange serving 70% of annual load and natural gas serving 30%

Current annual cost of natural gas: $_____(A)

1) Multiply

   annual gas consumption: _____GJ (total from utility bills)

   by 48.7 to estimate

   annual GSHP energy consumption: _____kWh (B)

2) Multiply (B) by your current electrical rate in $/kWh to estimate

   annual Cost of Electricity: $_____ (C)

3) Multiply (A) by 0.3 to estimate

   aeduced annual cost of gas: $_____ (D)

4) Add C and D to estimate the annual cost with hybrid geoexchange: $_____(E)

5) Subtract E from A to estimate the **Potential Savings from Geoexchange:** **$_____**

   (Assumes natural gas seasonal heating efficiency of 80%, GSHP average COP of 3.2)

Potential Geoexchange Savings vs. Propane

Hybrid System with geoexchange serving 70% of annual load and propane serving 30%

Current annual cost of propane: $_____(A)

1) Multiply

   annual propane use: _____Litres (total from utility bills)

   by 1.2 to estimate

   annual GSHP energy consumption: _____kWh (B)

2) Multiply (B) by your current electrical rate in $/kWh to estimate

   annual cost of electricity: $_____ (C)

3) Multiply (A) by 0.3 to estimate

   reduced annual cost of propane: $_____ (D)

4) Add C and D to estimate the annual cost with hybrid geoexchange: $_____(E)

5) Subtract E from A to estimate the **Potential Savings from Geoexchange:** **$_____**

   (Assumes propane seasonal heating efficiency of 80%, GSHP average COP of 3.2)

Readers should note that operations with simultaneous heating and cooling needs may achieve significantly higher energy cost savings than estimated by the formulas above. Optimal sizing of a geoexchange system may also lead to a higher or lower proportion of the annual load being provided by the heat pump than has been assumed above.

Regulatory Approval Process, Bodies and Agencies

Geoexchange systems must follow the same standard regulatory approval and permitting processes associated with conventional heating and cooling systems. These include those required by the Electrical Safety Authority, WorkSafe BC, BC Building Code, and building permit requirements of the local authority having jurisdiction.

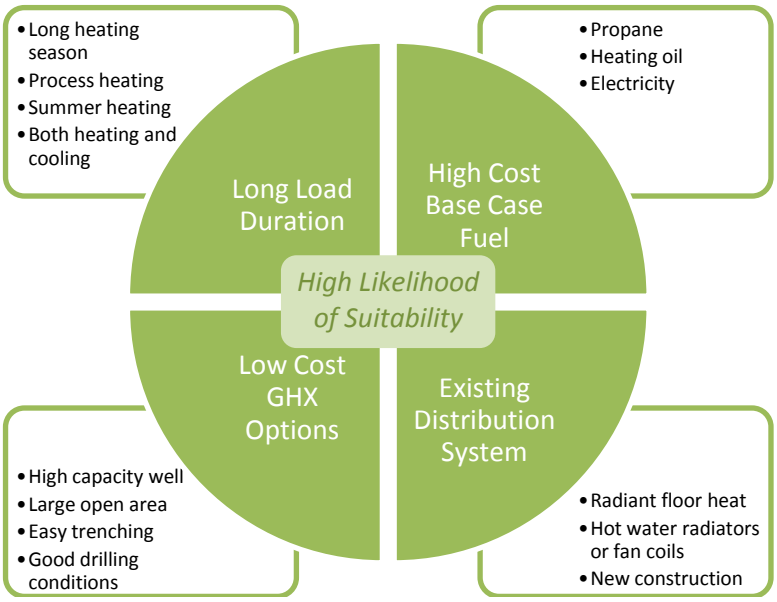
There are no regulatory approvals or permitting processes related specifically to geoexchange systems. However, excavation and drilling of ground heat exchangers must follow safety and environmental regulations protecting groundwater, surface water bodies, and other environmentally sensitive areas as listed below.

Producers should be aware of the following regulations and legislation particularly relevant to the construction of ground heat exchangers:

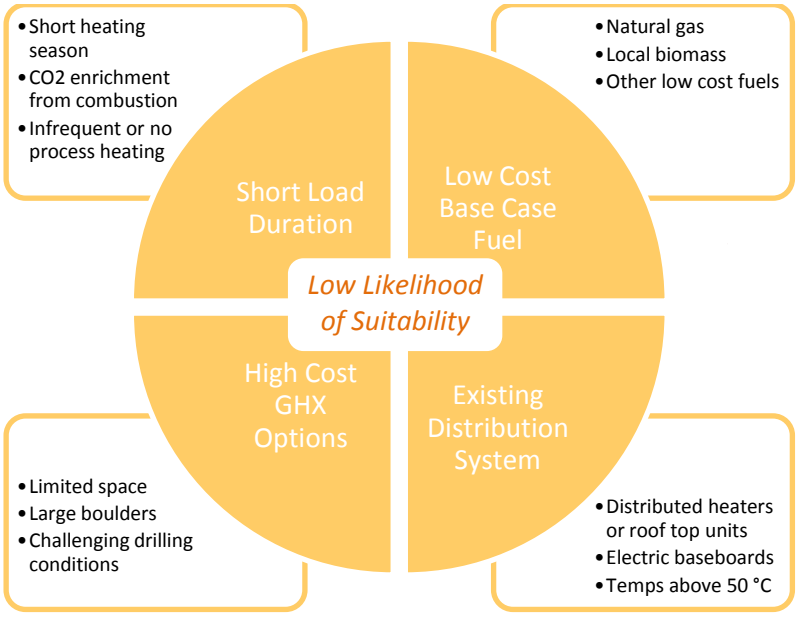
- BC Groundwater Protection Regulation
    - Requires the use of registered water well drillers (for closed loop vertical borehole systems and groundwater open-loop systems) and registered pump installers for groundwater systems
    - Specifies appropriate measures to protect groundwater aquifers
- Common property rights must be respected including utility rights of way and other easements
- BC Water Act and federal Fisheries Act
    - Require approval for any activities in and about water bodies and the disturbance of fish habitat
    - ***http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_96483_01***
    - ***http://laws-lois.justice.gc.ca/eng/acts/F-14/***

Predicting Site Suitability

Given the many variables that influence the profitability of geoexchange systems, it can be challenging to determine the suitability of geoexchange for a particular application without a detailed site-assessment. However, based on the common characteristics of profitable scenarios discussed in this Fact Sheet, owners can use the adjacent graphics to judge the likelihood that a geoexchange system will be suitable at their operation.



Some operations may have all the features of profitable systems listed under *High Likelihood of Suitability*. These operations are quite likely to benefit from a geoexchange system and owners are encouraged to take further steps to evaluate the possibility of using geoexchange technology at their site. Similarly, some operations may have all the features of unprofitable systems listed under *Low Likelihood of Suitability* and likely do not warrant further consideration of geoexchange without other additional information to suggest otherwise.



The majority of agricultural operations will have a combination of characteristics from both lists. For these operations, owners should weigh the benefits of the potential energy cost savings calculated on the previous page against the mix of features at their site. Operations with the potential for considerable savings and at least one of the features listed under *High Likelihood of Suitability* warrant a discussion with a professional to determine if a detailed evaluation is justified.

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