Geoexchange for
BC Public Sector Organizations

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Chair of the Board, GeoExchange BC

Carbon Neutral Government Symposium
December 3, 2014
WHO WE ARE

- Non-profit industry association
  - Private and public interests
  - Designers, installers, utilities, developers, municipalities, and government agencies

- Incubated 2002 - joint initiative BC Hydro and GVRD

- Evolved to non-profit association status in 2004

- Governed by volunteer elected directors who lead a series of activity-based committees
WHAT WE DO

- Provide leadership for geoexchange in BC
- Improve recognition of technology - merits and limitations
- Promote best-practices - unique BC settings
- Promote improvement of geox reliability and reputation
- Help build capacity to meet new code and regulation requirements (e.g., MoE, Building Code)
- Work with government, utilities, and other stakeholders
Energy from the sun warms the ground.

Heat exchange piping absorbs heat from the ground.

Loop piping carries heat into the building.

Geothermal heat pump transfers heat to the conditioned space.

Heat transfer process reversed for cooling.
GROUND HEAT EXCHANGE OPTIONS

Common Types of Ground Heat Exchangers (GHX’s)
COP LEVERAGING CONCEPT

2.6 units Renewable heat absorbed from ground

1 unit electricity from utility

= 3.6 units Heat Delivered to Building

Coefficient of Performance = \frac{\text{Heat delivered (3.6 units)}}{\text{Electricity used (1.0 unit)}} = 3.6
**GHG REDUCTION POTENTIAL**

Assume Building with:
- 500 kW peak heating load
- 2,000 equivalent annual full load hrs
- Located in BC Hydro service area

Then:
- Annual Heat demand = 1 million kWh/yr
- Converts to 3600 GJ/yr

**Gas-Fired Boiler Base Case**
- Assume AFUE = 90%
- Nat Gas input = 4000 GJ (3600 GJ output)
- 49.99 kgCO$_2$e/GJ emission factor

200 tons CO$_2$e

**Geoexchange**
- Assume heating seasonal system COP = 3.6
- Heat harnessed from ground = 2,600 GJ
- Compressor heat = 1,000 GJ (drawing on BC Hydro electricity)
- 4.0 kgCO$_2$e/GJ emission factor for BC Hydro electricity

4.0 tons CO$_2$e

98% Reduction from Base Case
GEOEXCHANGE BC GUIDELINE SET

- Comprehensive 5-volume guideline for BC
- First volume in 2004 - latest this year - 10 years in the making
- Meet a clear need for solutions for BC ground and climate settings
- Intended for larger commercial or institutional applications
- Dozens of BC authors and reviewers - wealth of “lessons-learned” experience
- *Best-in-Class* resource guide - truly unique to address challenges and opportunities in BC
- Although BC focused, received international recognition
Historical Perspective

- **Geoexchange 1.0 Era (1980 - 1999)**
  - Early adopters, “cottage industry”, trial & error approach
  - Dedicated and committed independent innovators

- **Geoexchange 2.0 Era (2000 - 2008)**
  - Very rapid (unsustainable) industry expansion with sharp rise in energy costs and new interest in GHG emissions
  - Latest Fad - over-promised and under-delivered - many poor performing systems

- **Geoexchange 3.0 Era (2009 - Present)**
  - Market correction, low natural gas price cause significant contraction for all renewables (including geoexchange)
  - Higher ratio of public sector projects
  - Renewed focus on quality and performance
ACTUAL OUTCOMES

- Too many poor outcomes during the Geoexchange 2.0 Era
- Perception of poor reliability - sometimes deserved
- Problems not the fault of the technology per se - **always** the fault of the way in which it is implemented
- Severe underperformance can result from:
  - Relatively small deficiencies that can be relatively easy to rectify (such as inadequate commissioning - very common)
  - Or fundamental deficiencies that may be difficult and expensive to rectify
GEOEXCHANGE – MORE SUSCEPTIBLE TO POOR OUTCOMES?

- Technically, geoexchange principle is simple....
  - Complexity lies in coordinating a varied, multi-disciplined team on work scopes straddling traditional divide between mechanical and civil engineering
  - Geoexchange teams include drillers, plumbers, excavators, refrigeration mechanics, electricians, engineers, architects - with no other reason to collaborate other than geoexchange
  - Effective team leadership and thoughtful procurement strategies are crucial to manage to favourable outcomes

- Concealed work - poor workmanship can be easy to hide
- Susceptibility to high expectations - low tolerance for poor performance
RESTORING CONFIDENCE

The Geoexchange 3.0 Era can be efficient and reliable if:

- Thoughtful attention to site suitability
- Careful selection of the type of system best-suited to the site
- Methodical design
- Careful and accountable installation
- Adequate site reviews by designer
- Appropriate QA/QC procedures during construction
- Methodical system commissioning
- Follow-up performance monitoring

GeoExchange BC Guidelines comprehensively address all of these considerations
GEOEXCHANGE BC GUIDELINES

- Part 1 - Site Suitability
- Part 2 - Design
- Part 3 - Commissioning
- Part 4 - Procurement

- User Guide
**PART 1 - SITE SUITABILITY ANALYSIS**

- Structured evaluation to assess common GHX types
- Avoid template thinking - no one-size-fits-all
- Respect geological variability that is common in BC
  - Gather sufficient information to choose best-suited GHX type
  - Gather sufficient information to adapt the specific design to take best advantage of the setting
- Reason this is important - GHX cost per unit capacity can vary by a factor of 10 times !!!

GeoExchange BC Part 1 Site Suitability Guideline describes a structured assessment method
STAGED SUITABILITY ASSESSMENT

Figure 5.1
Flow chart depicting three stage geoxchange suitability assessment process
RESPECT BC GEOLOGY

Whistler

Surrey
EXAMPLE SETTINGS - VANCOUVER
AGAIN - RESPECT BC GEOLOGY

Pine Pass Area

Dawson Creek Area

Rocky Mountain Front Ranges | Foothills | Prairies
GHX OPTIONS

Common Types of Ground Heat Exchangers (GHX’s)
Vertical Borehole Method

- Most adaptable method and often only suitable method for many sites
Adapt Design for Ground Conditions

Drilling silt and clay is easier than gravel, sand, boulders – therefore advantageous to drill a greater number of shallow boreholes in this setting.
Adapt Design for Ground Conditions

Drilling in granite is easier than gravel, sand, boulders – therefore advantageous to drill deeper boreholes in this setting.
Example: Schools with large Land to Building Area Ratio

- Unique opportunities for horizontal ground loop configurations
Chain Trench Method
Horizontal Directional Drilled (HDD) Method
Adapt Design for Ground Conditions

- Boulder and Cobbles (difficult to drill)
- Fine-grained clay and silt (easy to drill)
- Boulder and Cobbles (difficult to drill)
PART 2 - DESIGN

- GeoExchange BC Part 2 Design Guideline outlines design strategies and objectives particularly for BC settings
- Mechanical Design and GHX Design
- Intended to be used as a BC supplement to ASHRAE and other resource guides
- Theme - minimize temperature lifts in system for high performance and durability
- Incorporate QA/QC measures
  - Designer needs to thoroughly review installation (much concealed work)
DESIGN OBJECTIVES

- COP of 3.5 or higher routinely achievable
- Design Considerations
  - New or retrofit - retrofits can be very challenging
  - Central or Distributed heat pump systems
  - Hybrid combinations and apportioning loads
  - Low temperature distribution systems when possible
  - Seek simplicity when possible
PART 3 - COMMISSIONING

- Critical steps often overlooked
- Air is an enemy - thorough purging of air is critical
- Good designs simplify commissioning
- Significant number of systems are never commissioned properly
- Systemic and methodical approach is required
- GeoExchange BC Part 3 Commissioning guideline describes a methodical step-by-step approach
## Checklist Approach

![Pressure and Flow Test Record Sheet](Image)

**GeoExchange VCL GHX**

**Schedule C - Pressure and Flow Test Record Sheet**

<table>
<thead>
<tr>
<th>Project:</th>
<th>Project Number:</th>
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### I. Pressure Test

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<tr>
<th>Header ID</th>
<th>Date</th>
<th>Start Time</th>
<th>End Time</th>
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**Whole System:**

Full system pressure tested and witnessed by:

Signed: ____________________  (Witness)  Date: __________

### II. Flow Test

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<tr>
<th>Header ID</th>
<th>Date</th>
<th>Calculated Flow (U/L/hr)</th>
<th>Measured Flow (U/L/hr)</th>
<th>Inlet Pressure (psig)</th>
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Signed: ____________________  (Installer)
SYSTEM MONITORING - PRE-REQUISITE TO EFFICIENT PERFORMANCE
PART 4 - PROCUREMENT

- The Part 4 *Procurement Guideline* describes several types of procurement strategies.
- Tenders for GHX contracts need to provide adequate information for contractors so they can adequately manage risk and for owners to reduce costly change orders.
- Poor tender packages lacking crucial information is a very common problem plaguing the industry.
Successful geoexchange systems manage to **engage the right people, on the right scope, at the right time.**

With cost for GHX capacity varying by factor of 10x, skilled guidance can deliver value.
GEOEXCHANGE SYSTEM COST

Cost ranges due to site setting and skill of designer to adapt to setting
Cost/kW Capacity ranges from less than $300 to more than $2000
PORTFOLIO ASSESSMENTS

- Portfolio assessments - more benefit at less cost
  - Units costs for geox capacity vary greatly from site-to-site
  - Retrofit compatibility varies greatly from site-to-site
  - Future life and maintainability of existing systems varies
- Some buildings much better suited than others for geoexchange
- Decision matrix approach

<table>
<thead>
<tr>
<th>Building</th>
<th>Ground Setting</th>
<th>Retrofit Compatibility</th>
<th>Existing System Needs Upgrade</th>
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FURTHER QUESTIONS

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Chair of Board (Volunteer Position)

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