Highlights of the Technical Feasibility Study of the Geothermal Capability of the Penobsquis Mine
Presentation to Town of Sussex
March 26th 2018 6:00PM

Presentation Outline

What is Geothermal Energy
Geothermal Energy in Mines
Geothermal Systems Overview
Decommissioned Penobsquis Mine
Example Geothermal Applications
Highlights of Results
Key Assumptions
Summary
What is Geothermal Energy

It is the heat produced and stored in the earth.
Heat radiates out from the centre to the surface.

What can geothermal energy be used for:
- Power generation – High Temperatures
- Heating and cooling – Low temperatures

http://www.kim-vinet-ski.com/geothermal-energy/

What is Geothermal Energy

High Temperature Geothermal
- Power Generation.
- Temperatures greater than 180 degrees Celsius.

GS diagram (source: DOE, Geothermal Technologies Program)
http://www.thinkgeosenergy.com
What is Geothermal Energy

Low Temperature Geothermal
Temperatures less than 150 degrees Celsius.
Used in heating and cooling

Geothermal Energy in Mines

Mine Water Geothermal Projects
Studies estimate 20 examples of operational geothermal systems on mine sites.
Examples are from all over the world in a variety of mine types.

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
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<tbody>
<tr>
<td>Early 1900's</td>
<td>USA - Henderson molybdenum mine</td>
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<tr>
<td>1984</td>
<td>Germany - Heinrich coal mine</td>
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<td>Late 1980's</td>
<td>Canada - Springhill, Nova Scotia, Coal Mine</td>
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<td>1994</td>
<td>Germany - Abandoned tin mine</td>
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<td>1995</td>
<td>USA - Park Hills, Missouri, lead mine</td>
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<td>1997</td>
<td>Germany - Abandoned tin mine</td>
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<td>1998</td>
<td>Norway - Follidal mine, Hedmark County</td>
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<tr>
<td>1999</td>
<td>UK - Shettleston, Scotland, coal</td>
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<tr>
<td>2000</td>
<td>UK - Lumphinnan, Scotland, coal</td>
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<tr>
<td>2000</td>
<td>Germany - Zollverein coal mine, Katernberg, Essen</td>
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<td>2007</td>
<td>Germany - Shaft 302, Marienberg mine, Sachsen, uranium mine</td>
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<td>2006</td>
<td>Canada - Goyer Quarry, Quebec</td>
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<td>2009</td>
<td>Russia - Novoshakhhtinsk, coal</td>
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<td>2009</td>
<td>Netherlands - Heerlen, coal</td>
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<tr>
<td>2010</td>
<td>Spain - Hunosa, coal</td>
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Geothermal Energy in Mines

Springhill – Nova Scotia
Abandoned Coal Mine workings
System operational since 1989
100 m well depth
Close to the Town of Springhill

Geothermal Systems Overview

Open Loop Systems

Water pumped from a borehole and circulated through a heat-pump and then discharged back into the ground.

Three main designs:
- Single well;
- Double well;
- Surface Loop.

Basic examples of Open Loop Geothermal Systems Based on Lund (2004).
Geothermal Systems Overview

Closed Loop Systems

In a closed loop system, no water is extracted or discharged to the environment. Heat exchange occurs through a closed loop of piping buried in the ground. There are two types of closed loop system:
- Vertical;
- Horizontal:

Open Loop

Advantages:
- Construction costs
- Efficiency

Disadvantages:
- Requires good flow
- Require hydrogeological studies
- Water quality important
- Higher pumping costs (extracting water).
Geothermal Systems Overview
Open Loop Vs Closed Loop

Closed Loop
Advantages:
- No removing groundwater
- Low maintenance and high durability.

Disadvantages:
- Less efficient than open loop
- Construction costs

District Heating Cooling Systems

A district loop can be used in open or closed loop configurations. A district loop distributes target water to several buildings. Piping layouts can be either one or two pipes. In a one-pipe heating system, all users are connected to the same pipe. In a two-pipe heating system, all users have their own lines.
Decommissioned Penobsquis Mine

Approximately 10 km north-east of Sussex
Long history of mining in the community
Mined Potash and Salt
Cut and fill mine
Production
  1983 – 2015
Closure
  January 2016
Flooding started in early 2017
Decommissioned Penobsquis Mine

Key questions:
- Where are the mine workings
- Where is the fluid (brine / water)
- What is the temperature of the fluids
- What is the water quality of the fluid
- How much fluid is there (volume)
- What technologies can safely access the fluid

Example Geothermal Applications

**Evaluation Process**

- Looked at range of examples
- Determined heating and cooling needs
- Evaluated examples with open and closed loop systems

Results provided:
- Estimated costs for the geothermal system;
- Estimated energy consumption;
- Energy savings;
- Maintenance costs;
- CO₂ emissions reduction; and
- Payback period.
Example Geothermal Applications

Example Operations

Five (5) individual user examples
4 and 20 Acres greenhouses - heating only

Six (6) District loop examples
combination of greenhouses (4 and 20 Acres) and refrigeration warehouses - heating and cooling

Eleven (11) total cases
All examples were evaluated with open and closed loop systems

Twenty-Two (22) example results

Results Highlights

Open Loop systems capital costs were 3 to 11 times lower than closed loop systems;

Closed loop systems had much lower energy consumption and lower maintenance compared to open loop systems.

Open loop payback periods were 2 to 8 times faster than the closed loop examples.

2 of the 22 examples yielded payback periods of less than 10 years:
20 Acre Greenhouse and 10 Refrigeration Warehouse - 2 Pipe System
20 Acre Greenhouse and 10 Refrigeration Warehouse - 2 Pipe System with a supplemental boiler
Results Highlights

Best Suited Example:

20 Acre Greenhouse and 10 Refrigeration Warehouse - 2 Pipe System with a supplemental boiler
- Capital Investment ~ $11.3M
- Annual Operational and Maintenance Costs ~ $98,000
- System Energy Consumption ~ $1.9M
- System Savings ~ $1.7M
- Pay Back period ~ 7 years
- Green house gas reduction ~ 12,400 tonnes of CO₂

Capital Cost Sharing:
- Utility ~ $5.7 M
- Collective Users ~ $5.6 M

Key Assumptions

In gathering the information to investigate the mine’s geothermal potential and its initial technical feasibility, a number of assumptions were made.

Some of assumptions made during this study were:

- Water / Brine Level
- Temperature of the Water / Brine
- Chemistry of the Water / Brine
- Well Design
Questions ??