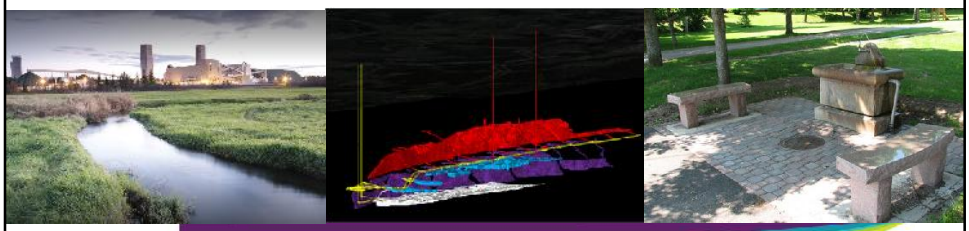
Highlights of the Technical Feasibility Study of the Geothermal Capability of the Penobsquis Mine

Presentation to Town of Sussex

March 26th 2018 6:00PM



Sussex NEW BRUNSWICK Gateway to the Fundy Experience

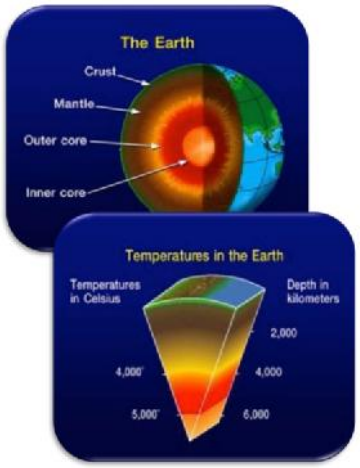
Presentation Outline

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

2

What is Geothermal Energy

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



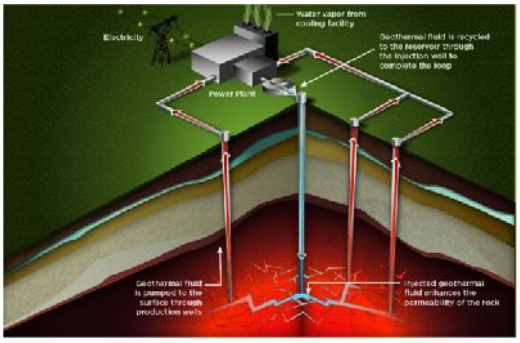
- What can geothermal energy be used for:
  - Power generation – High Temperatures
  - Heating and cooling – Low temperatures

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

3

What is Geothermal Energy

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

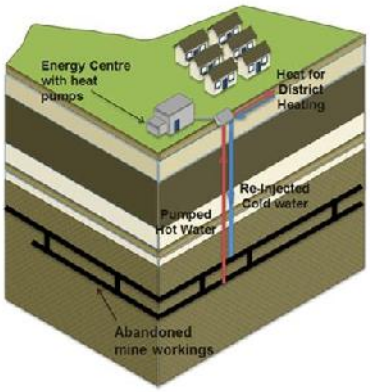


GS diagram (source: DOE, Geothermal Technologies Program)
http://www.thinkgeoenergy.com

4

What is Geothermal Energy

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



5

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.

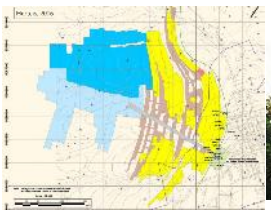
Date	Location
Early 1900's	USA – Henderson molybdenum mine
1984	Germany – Heinrich coal mine
Late 1980's	Canada – Springhill, Nova Scotia, Coal Mine
1994	Germany – Abandoned tin mine
1995	USA – Park Hills, Missouri, lead mine
1997	Germany – Abandoned tin mine
1998	Norway – Folldal mine, Hedmark County
1999	UK – Shettleston, Scotland, coal
2000	UK – Lumphinnan, Scotland, coal
2000	Germany – Zollverein coal mine, Katernberg, Essen
2007	Germany – Shaft 302, Marienberg mine, Sachsen, uranium mine
2006	Canada – Goyer Quarry, Quebec
2009	Russia – Novoshakhtinsk, coal
2009	Netherlands – Heerlen, coal
2010	Spain – Hunosa, coal

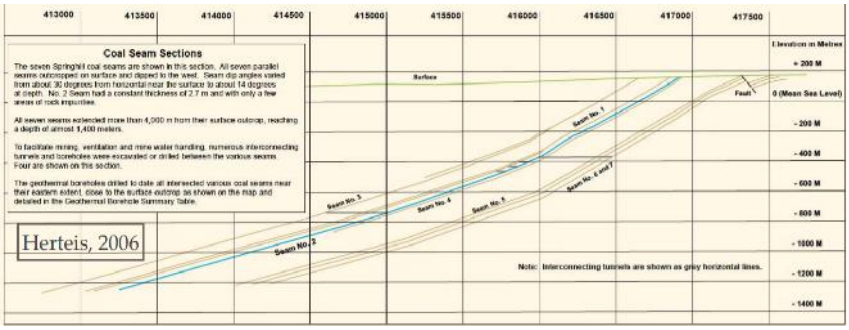
6

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



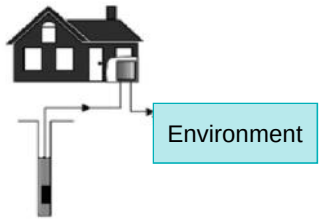


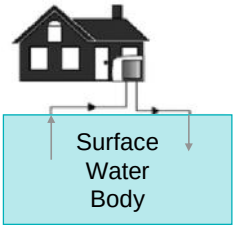
7

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.





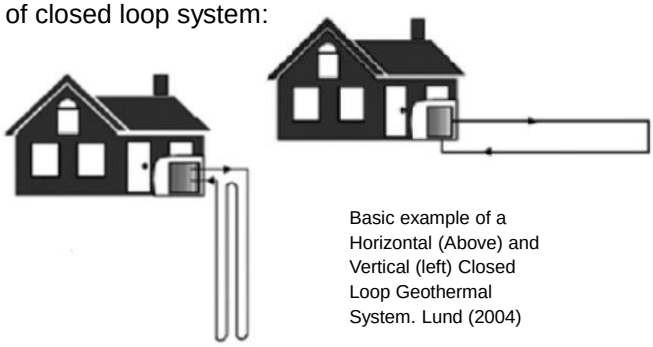
Basic examples of Open Loop Geothermal Systems Based on Lund (2004).

8

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:



Basic example of a Horizontal (Above) and Vertical (left) Closed Loop Geothermal System. Lund (2004)

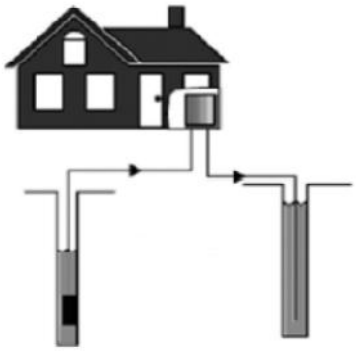
9

Geothermal Systems Overview

Open Loop Vs Closed Loop

Open Loop

- Advantages:
  - Construction costs
  - Efficiency
- Disadvantages:
  - Requires good flow
  - Require hydrogeological studies
  - Water quality important
  - Higher pumping costs (extracting water).



10

Geothermal Systems Overview

Open Loop Vs Closed Loop

Closed Loop

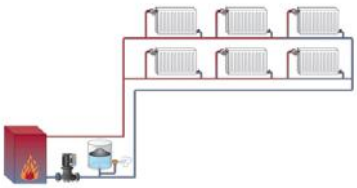
- Advantages:
  - No removing groundwater
  - Low maintenance and high durability.
- Disadvantages:
  - Less efficient than open loop
  - Construction costs

11

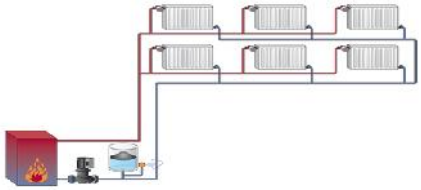
Geothermal Systems Overview

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.



Basic example of a One-Pipe Layout, Heating. (Groundfos.com)

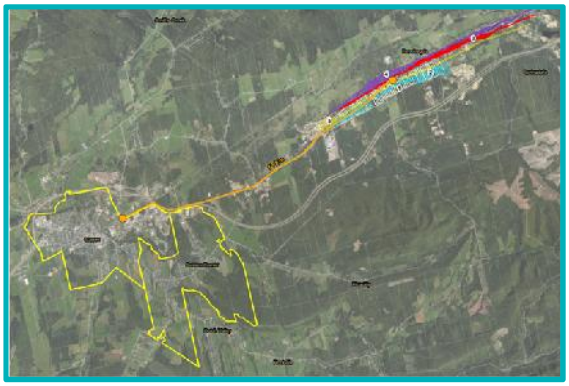


Basic example of a Two-Pipe Layout, Heating. (Groundfos.com)

12

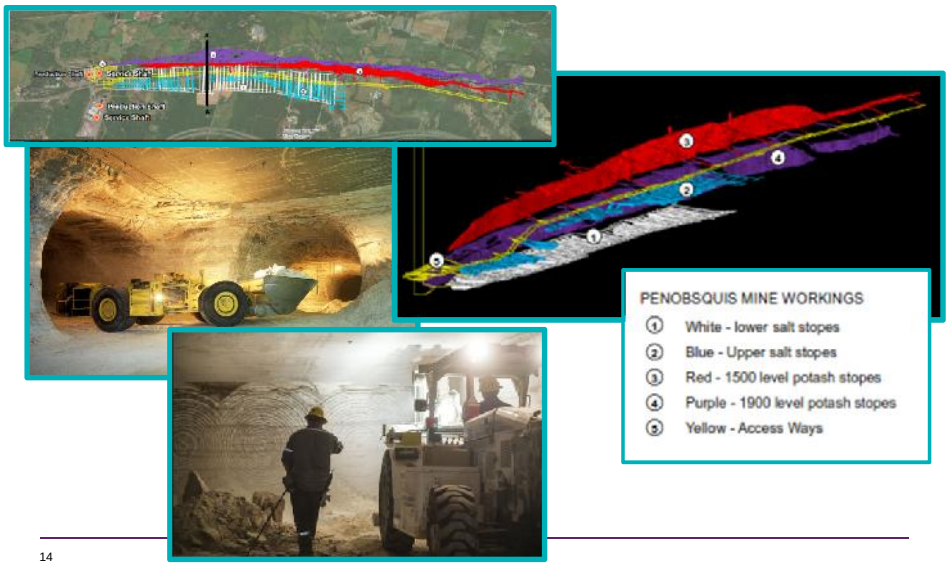
Decommissioned Penobsquis Mine

- 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



13

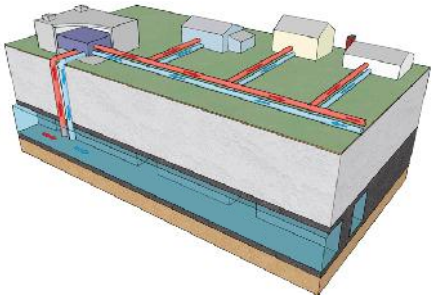
Decommissioned Penobsquis Mine



14

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



15

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;
  - CO_2 emissions reduction; and
  - Payback period.

16

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

17

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

18

Results Highlights

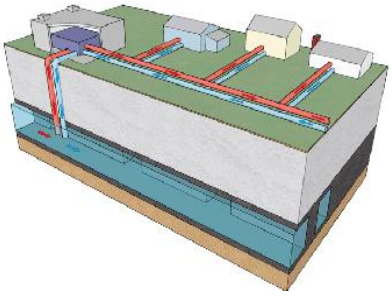
Best Suited Example:

- 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 CO_2
- Capital Cost Sharing:
  - Utility ~ $5.7 M
  - Collective Users ~ $5.6 M

19

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**



20

Questions ??

21