
NT Geoscience Forum 2018

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High-Grade Geothermal Energy

This is not what I am talking about!

Hudson Ranch, Imperial valley, CA, USA
Geothermal Energy in Canada??

Geological Survey of Canada
Steve Grasby’s work
Geothermal Methods...

- Deep, High T Geothermal? 
  Not in 95% of Canada!
- Shallow local geothermal with heat pumps is used - energy storage
- EGS - Enhanced Geothermal Systems
  - “Intermediate-grade” thermal energy
  - “Heat mining” at depths of > 4 km (T > 70°C)
  - Large volumes of rock, but little water...
- Let’s look at EGS possibilities in a cold Northern Climate...
So Here is the Problem...

- Deep geothermal needs a high enough T for co-generation - power + heat
- And we need to drill at least 3-4 km deep to get 60-70°C
- Shallow geothermal (GSHP) becomes inefficient because the ground cools more and more each year
- But if the shallow ground T is OK and is maintained annually - heat pumps have a COP of 3 to 4!! Good use of power.
Geothermal Energy in the North

**Open Loop System**
- 2 wells
- Water body

**Closed Loop System**
- Vertical
- Horizontal
- Geothermal piles

**Heat Storage**
GSHP T-Balance

- Heating dominates in the north

Italy example
Recharging a Thermal Battery

- Heating is $3 \times$ to $10 \times$ more important in Northern climates!
- So..., the ground will cool each season with GSHP shallow geothermal... and efficiencies drop substantially.
- Solution: **Recharge** the Thermal Battery

Options...
- Waste heat
- Solar heat
- Deep geothermal heat (EGS)
EGS and Warm Geothermal

EGS from hot, dry rock
- Little to no intrinsic permeability
- Heat exchange to a working (circulating) fluid is needed (convection is too slow)
- Rock mass permeability must be increased
- At least two wellbores are needed

EGS from hot sedimentary fluids
- Reservoir must be hot enough for application
- ...and permeable enough to produce volumes needed
- Can be integrated with O&G operations
- Single (production) well suffices, shallow disposal

0.5 MW geothermal minimum in North??
The EGS Concept...

1. Water lagoon
2. Pump house
3. Heat exchanger
4. Turbine hall
5. Production well
6. Injection well
7. Hot H₂O to district heating
8. Porous sediments
9. Observation well
10. Crystalline bedrock

What V is needed?
Power and heat must meet Oct-April needs (Jan ambient ~ -20°C) (not July!)

Geothermal use across Northern Canada means T(liquids) < 70-80°C

Can we generate power?...

So, to use this energy, we need---

Rankine Cycle engines for electricity + Direct heat use for buildings and homes
## Rankine Cycle Use

- Rankine cycle use depends on
  - T of fluids
  - Ambient T
  - Cycle ΔT
  - Liquid rate

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<thead>
<tr>
<th></th>
<th>Yellowknife</th>
<th>Estevan SK</th>
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<tbody>
<tr>
<td>Fluid T</td>
<td>70°C</td>
<td>115°C</td>
</tr>
<tr>
<td>Ambient T</td>
<td>-20°C (winter)</td>
<td>+20°C (summer)</td>
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<tr>
<td>Efflux T</td>
<td>20°C</td>
<td>65°C</td>
</tr>
<tr>
<td>Delta-T</td>
<td>50°C</td>
<td>50°C</td>
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- Rankine cycle efficiency is OK at low T!
- Low-T condensing fluid needed
- Efflux has a reasonable T
- We can recharge the thermal battery and also generate EGS power in winter!
Deep Geothermal Heat Storage

Deep reservoir
0.5 km³

150-200°C

Absorber Tubes
Parabolic reflectors
To heat storage

Geothermal Energy in the North

Parabolic reflector
Focal point

From Wikipedia
https://upload.wikimedia.org/wikipedia/commons/b/b5/Parabolic_trough.svg
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IIT-B
Energy Storage, GSHP & EGS

- We can store thermal energy in a shallow (30-300 m) geothermal system.
- We can recharge this annually, but from where? EGS? Solar? Waste heat?
- EGS can give us power and the excess heat can be stored.
- Fluids are recycled to depth (binary system), so there are few losses.
- In cold weather, GSHP for home heating.
- Summer solar can be “stored” as heat.
This is Like a Hybrid Car!

- Heat geostorage is the **battery**
- EGS is the **gasoline** driving the system
- Solar heat or waste heat may be used to charge the battery ("plug in")
The Hybrid Car Analogy

- Heat geostorage is the battery
- EGS is the gasoline
- GSHP is the converter

I drive a Prius V
Low T: some power... ...and district heating.
Interwell Communication...

- Surface casing
- Cement
- Production casing
- Wellbores
- Overburden rocks
- Hot dry rock reservoir
- Hydraulic fracture stages

- 200-600 m
- 3–7 km
- 1500-2000 m
The Binary EGS Cycle

Special Rankine engine

Fractured region

Extracting GeoEnergy

https://serendipitousscaveinger.wordpress.com/tag/enhanced-geothermal-systems/
**Climeon™ (“climb-on”)**

- Scalable and modular (150 kW)
- Low-pressure (vacuum), low-T alcohol-type working fluid
- Can operate at $\Delta T$ of 50°C: e.g.: 70°C/20°C

Climeon claims 2× efficiency of a “classic” ORC system

[https://climeon.com/](https://climeon.com/)
Geothermal Energy in the North

EAVOR™ SYSTEM

Power unit 1

Power unit 2

3 to 5 km apart

3-5 km

EAVOR™ SYSTEM

Main loops

Laterals

https://eavor.co
Conclusions...

- A “Hybrid” EGS/GSHP system has definite advantages over a simple EGS

Technology is evolving:
- Cheaper deep drilling
- Better energy extraction systems
- Better GSHP systems
- Potential novel concepts

- In the North, competition is with diesel, perhaps at costs of $0.50-1.50 /kWh

- It is time to revisit geothermal systems for remote communities...
Environmental Rock Mechanics

Thanks to NT Geosci. Forum and all involved!