Kickstarting the Industry in Canada

Catherine Hickson, Ryan Dick, Tiffani Fraser, Steve Grasby, Katie Huang, Jacek Majorowicz, Kirsten Marcia, Mafalda Miranda, Fran Noone, Jasmin Raymond, & Jeff Witter,
Geothermal Resources Council
International Program
Monday, Sept 16, 2019, Palm Springs, California
Celebrating 45 years of existence since being founded in 1974 as the Canadian Geothermal Association, the Association was rebranded in 2018 as Geothermal Canada. Building on this early legacy of Canadian geothermal pioneers, the renewed organization is focused on providing a venue to discuss technical and academic aspects of the industry providing a forum for research, innovation, and collaboration. Join us!
Pan Canadian Society for Geothermal Research, Innovation & Collaboration

The objectives of the Society are:
To advance science and promote geothermal research in Canada
To promote innovation in Canada in geothermal research
To foster collaborative investigations between academia, companies and organizations in the field of geothermal research
Current Board of Directors, Geothermal Canada
(attending GRC ⭐️)

Steve Grasby
Katie Huang
Bastien Poux
Maurice Dusseault
Ryan Dick

Jasmin Raymond
Catherine Hickson
Jeff Witter
Mafalda Miranda
Tiffany Fraser

Kirsten Marcia
https://www.geothermalcanada.org/

Grant Ferguson
Geothermal Canada Internationally

https://www.geothermalcanada.org/
Some members of Geothermal Canada
Upcoming 2019 Conferences

CGSD2019

The conference  Abstract and schedule  Student Travel Assistance Program  Speakers  Partners and sponsors  More...

Mafalda Miranda

1st Canadian Geothermal Students' Day

21 - 22 November 2019  Québec City

https://www.geothermalcanada.org/
THE IMPORTANCE OF GEOTHERMAL TO CANADA

https://www.geothermalcanada.org/
Much of Canada’s economy has been driven by the price of hydrocarbons. Geothermal has been driven by these peaks and valleys. During the mid 1970s (A), during the world oil crises the Canadian government invested approximately 100 million (1974-1985: 2019 dollars) in geothermal exploration. Again in the mid to late 2000s (B), geothermal energy saw a significant increase in interest from the private sector. In both cases, interest plummeted when the price of oil also plummeted. Now the increased interest is being driven by a change in thinking; decreasing GHGs and sustainability.

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Extreme climate

Arctic to subarctic climate
- Permafrost conditions
- High heating loads
  - > 8000 degree-days
- Mean annual temperatures of less than zero degrees Celsius

Most Energy needs are supplied by fossil fuels
Geothermal can:
- Generate electricity.
- Heat buildings.
- Carbon offset potential.
- Reliable alternative to hydrocarbons.

THE POWER OF ΔT (TEMPERATURE DIFFERENCES)

https://www.geothermalcanada.org/
The Power Of $\Delta t$ (Temperature Differences)

Northern Alberta

January temperatures: daily averages

<table>
<thead>
<tr>
<th>High °F</th>
<th>Low °F</th>
<th>Place</th>
<th>High °C</th>
<th>Low °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>-4</td>
<td>Cold Lake</td>
<td>-10</td>
<td>-20</td>
</tr>
<tr>
<td>2</td>
<td>-17</td>
<td>Fort Chipewyan</td>
<td>-17</td>
<td>-27</td>
</tr>
<tr>
<td>10</td>
<td>-8</td>
<td>Fort McMurray</td>
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<tr>
<td>5</td>
<td>-14</td>
<td>High Level</td>
<td>-15</td>
<td>-26</td>
</tr>
<tr>
<td>15</td>
<td>-3</td>
<td>Slave Lake</td>
<td>-9</td>
<td>-19</td>
</tr>
</tbody>
</table>

Fig. 3  Departures from the 1961–1990 mean of area average mean temperature (°C). Bold curves are 11-year moving averages.
Importance of heat

Energy consumption: Huge requirement for space heating in Canada.

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2017 projection: Canada’s Energy Future

- Actual consumption 11 407 PJ/y
- ~0.7 %/y increase
The Future Energy Alternatives for Canada – kickstarting an industry

The green economy as a driver of change in Canada.

Federal funding (Natural Resources Canada) for Geothermal projects is finally coming to fruition. Close to $70 million is being committed to support geothermal projects such as:

**Development Projects:**
- Alberta #1
- DEEP

**R&D:**
- Barkley Project Group
- Eavor
- Razor
- Geological Survey of Canada/NRCan

www.cremtl.qc.ca

https://www.geothermalcanada.org/
GEOTHERMAL POTENTIAL OF CANADA

https://www.geothermalcanada.org/
Why Little Geothermal in the Current Energy Balance in Canada?

- Installation cost remains important
- Strong competition from other generation sources
  - (natural gas and hydro)

National Objective
- Reduce costs to move geothermal into the energy transition
- Make geothermal a viable option to other renewables.

How to Achieve?
1. Characterize resources
2. Develop new technologies
3. Improve system design and operation
4. Infusion of Government funding for R&D and development

https://www.geothermalcanada.org/
Why Little Geothermal in the Current Energy Balance in Canada?

How to Achieve?

1. Characterize resources – continued research funded by government to help define the resource and reduce development cost and risk.

2. Develop new technologies
   • Razor, Eavor, INRS and other university-based research
   • Invest in more EGS research

3. Improve system design and operation
   • Razor, Eavor, INRS and other university-based research

4. Infusion of Government funding for research, innovation and development
   • About $70 million in Federal funding has been committed to development and research, innovation and development projects

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From assessment to development

- Western Canada sedimentary basin (BC, Yukon, Alberta, Saskatchewan)
- Fault controlled non-volcanic systems (BC)
- Volcanic systems (BC)
- Northern potential in sedimentary basins (Nunavut, Yukon, NWT)
- Crystalline basement (Canadian Shield)

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Emerging Renewable Power Program

- Over $200 million available funding
- Minimum requirement is to produce 4MWe
- As of Sept. 2019, two geothermal projects have been funded.

Development Funding

Alberta #1: South of Grande Prairie, Alberta
$25.4 Million

DEEP: South of Estevan, Saskatchewan
$25.8 Million

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Research Funding

Garibaldi Volcanic Belt Project

Waste heat from Oil & Gas

Clarke Lake Project

Deep geoexchange

~$20 Million in funding

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A Scopus search with “geothermal” in keywords, title and abstract revealed that 11,872 documents have been published in this field over the past five years, from the beginning of 2014 until the end of 2018. Publications were sorted according to country affiliation of authors. Canada is rank seven, with 464 publications, after the six countries with most contributions to the geothermal literature over the past five years, namely the United States of America (2,498), China (2,055), Germany (999), Italy (775), United Kingdom (571) and Japan (498). Hence, the Canadian contribution to geothermal science remains outstanding, given that the population of Canada is smaller than all the above countries and that geothermal power is not yet produced in the Canada, although geothermal direct use is widespread with utilization of geothermal heat pumps from coast to coast.

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Northern Geothermal Potential Research Chair

- Resource assessment of northern mines and communities
- Adapt technologies to deal with arctic to subarctic climate

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GEOTHERMAL PROJECTS IN CANADA

https://www.geothermalcanada.org/

https://www.geothermalcanada.org/
Northwest Territories Government Initiatives

- Potential in the northern portions of the Western Canada Sedimentary Basin
- Adapt technologies to deal with arctic to subarctic climate
- Workshop in Yellowknife, November 23, 2018 to provide a broad technical overview of the geothermal energy options available in the NWT and Northerners

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Yukon Government Initiatives

Yukon’s geothermal potential could be significantly more than the current energy supplied by Yukon’s renewable (dominated by hydro) electrical system (90 MW).

Low mean annual temperatures, significant heating degree days and communities with diesel generation lend themselves to investigation of the geothermal potential of the region, including Enhanced Geothermal Systems (EGS).

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Yukon Government Initiatives

Work in 2019 includes:

• Modeling regional heat flow in the mid to shallow crust;
• Calculating potential heat production from young granites;
• Direct measurement of thermal gradient in two ground temperature monitoring wells; and
• Geophysical surveys over an active deep crustal fault structure.
• Workshop and field visit to Chena Hotsprings, Alaska (Thank you Bernie Karl!)

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British Columbia

Hot sedimentary basins
Fault controlled systems
Volcanic systems

• Current hurdles to development in British Columbia
  • Inability to obtain a power purchase agreement
  • Significant hydro resources

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British Columbia

Re-looking at the Garibaldi Volcanic Belt, Host of the Mount Meager Geothermal field

*Joint project with Federal and Provincial funding*

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Applicant for NRCan’s ERPP program with Fort Nelson First Nation and Saulteau First Nation as the proponents.

Significant research effort and a number of papers published on the potential. NRCan funding for community capacity building.

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Western Canada sedimentary basin (WCSB)

- Significant progress in Saskatchewan with DEEP.
- Alberta #1 just approved.
- Clarke Lake submitted.
- Underlying questions to address –
  - How much heat is it possible to recover and at what cost?
  - Use of inactive oil and gas wells

(Weides and Majorowicz 2014)
Alberta #1 is a consortium composed of Terrapin Geothermics, PCL Construction, Municipal District of Greenview and NRCan Emerging Renewable Power Program. The target is Beaver Hill Lake strata below the Duvernay (tight shale gas) @120°C and 3,500 – 4,000 m in depth. Visit the poster session to learn more:

**TECHNOLOGY TRANSFER BETWEEN OIL & GAS AND GEOTHERMAL APPLICATIONS**

Tuesday 5pm – 7pm: Alberta’s Western Canada Sedimentary Basin’s First Electrical Geothermal Project (Catherine J. Hickson et al.)

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Saskatchewan based company (https://www.deepcorp.ca)
• Aiming to develop 100 – 200 MW of scalable baseload power and industrial heating applications
• Secured Canada’s first geothermal Power Purchase Agreement (PPA) – 25-year contract
• Drilled a successful 3,530 metres test well with above modelled temperatures (125-130°) (deepest well in SK)
• Currently underway with flow testing, converting the well into an injection well and will be drilling a second well (production) in October to establish the well pair required for long term testing

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East of the Prairies

Smith and Burgess, 2004

https://www.geothermalcanada.org/
Quebec - Geothermal Heat Pump System to Heat the Éléonore Mine

https://www.geothermalcanada.org/
Quebec - St. Lawrence Lowlands – 3D Temperature Model

1. Resource characterization

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INNOVATION

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Mining influenced technical advancements

- Miniaturization of sensors, controls and electronics
  - Mini mass specs and other sensors
  - Small enough to mount on drones and remote vehicles
- Intransitivity of new instruments
- Remote controlled vehicles
- High powered computing
- Advanced software for 3D analysis
- New and more sensitive satellites
- Hyperspectral imaging
- Rapid infield hydrogeochemistry testing
- Drilling techniques in permafrost
- Adaptive technologies for arctic to sub arctic conditions.

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Arctic conditions technical advancements
eq. thermally enhanced pipe

- For ground-coupled heat pumps
- 75% more conductive (0.7 W/mK)
- Reduce borehole thermal resistance
- Decrease required borehole length (5 – 25%)

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Oil & Gas influenced technical advancement

• Drilling technology
• Expertise in sedimentary basins
• Well integrity
• Reservoir modeling and testing
• Directional drilling

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Building on experience

C-FER works in partnership with the global energy industry to advance safety, environmental performance and efficiency. We provide full-scale testing and specialized engineering consulting services from our world-class facilities in Edmonton, Alberta, Canada. C-FER is a not-for-profit, fee-for-service subsidiary of Alberta Innovates.

Please join Wayne Klaczek in the Madera Room at 5:00 PM today as he presents *An Introduction to Flow Control Devices and the Potential Benefits to Geothermal Applications.*

https://www.geothermalcanada.org/
Using the latest analysis methods and our world-class full-scale testing laboratories, C-FER can help in areas such as:

**Thermal Well Design** (Casing and Tubing Connection Testing, Sand Control, Thermal Cements)

**Well Integrity** (Cement Integrity, Well Remediation Options, Risk Assessments)

**Well Log Interpretation** (Well Xplore™ for casing deformation analysis)

**Scale Management** (Design and Testing of Scale Mitigation Approaches)

**Corrosive Environment Testing** (Coupon and Full-Scale, Material Sampling, Protective Coatings)

**Flow Assurance** (Pump Reliability Analysis, Accelerated Aging Tests, Erosion Testing, Erosion Failure Analysis)

**Production Optimization** (Performance Testing of Full-Scale Production Equipment and Processes, Flow Control Devices, Artificial Lift Systems, Multiphase Flow Modeling)

**Subsidence Management** (Wellbore Thermodynamics Modeling, Casing Buckling Evaluation, Well Design)

https://www.geothermalcanada.org/
THANKS!!
KICK STARTING AN INDUSTRY

Don’t forget! Join us in Quebec City, November 21-22, for a Geothermal Students’ conference

https://www.geothermalcanada.org/