Geothermal Energy in Canada: Heating Up

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ABSTRACT

There is a growing consensus in Canada and around the globe regarding the need for a clean energy transition. In the context of this shift towards renewable energy sources, how is geothermal energy fairing in Canada? What can be done to catalyze growth in the geothermal energy industry? This paper will review each province and territory's geothermal energy landscape, including contextualized benefits, relevant project developments, challenges and recommendations. This will effectively serve as a "state of the union" for geothermal energy development in Canada.

1. Introduction

The Canadian Geothermal Energy Association (CanGEA) is the collective voice of Canada's growing geothermal industry. Founded in 2007, CanGEA's mandate is to accelerate the development of geothermal exploration throughout Canada. CanGEA operates on three pillars – education, outreach and policy advocacy – with the goal of unlocking Canada's geothermal energy potential.

The general sentiment in Canada towards geothermal energy development has improved as a result of a growing appetite for clean energy sources, and CanGEA's continued public outreach efforts. A recent poll found that 61 percent of Canadians have a positive opinion towards geothermal energy as an energy source.[1] These findings are noteworthy given that geothermal energy has only recently become a part of the public discourse in Cana

[1]Cision, "Four-in-Five Canadians Support Resource Development Projects," 2018.

da. The poll also provides a useful baseline measurement by which to gauge the efficacy of future public outreach efforts.

The following paper provides a briefing on the geothermal energy resources available in Canada, a provincial and territorial review of their respective geothermal energy landscapes, and a high-level summary of federal considerations in order to paint a comprehensive picture of Canada's geothermal energy industry.

1.1 Geothermal Resources in Canada

The potential for geothermal energy spans the nation, though capacity and potential usages vary widely. Western Canada is commonly identified as having higher quality resources, thereby, the area with highest potential for geothermal development. However, direct use projects are gaining traction in several Canadian regions. Figure 1 depicts the locations and types of geothermal resources that can be found in Canada.[2] Canada is the only continental North American country yet to produce electricity from geothermal energy resources.[3]

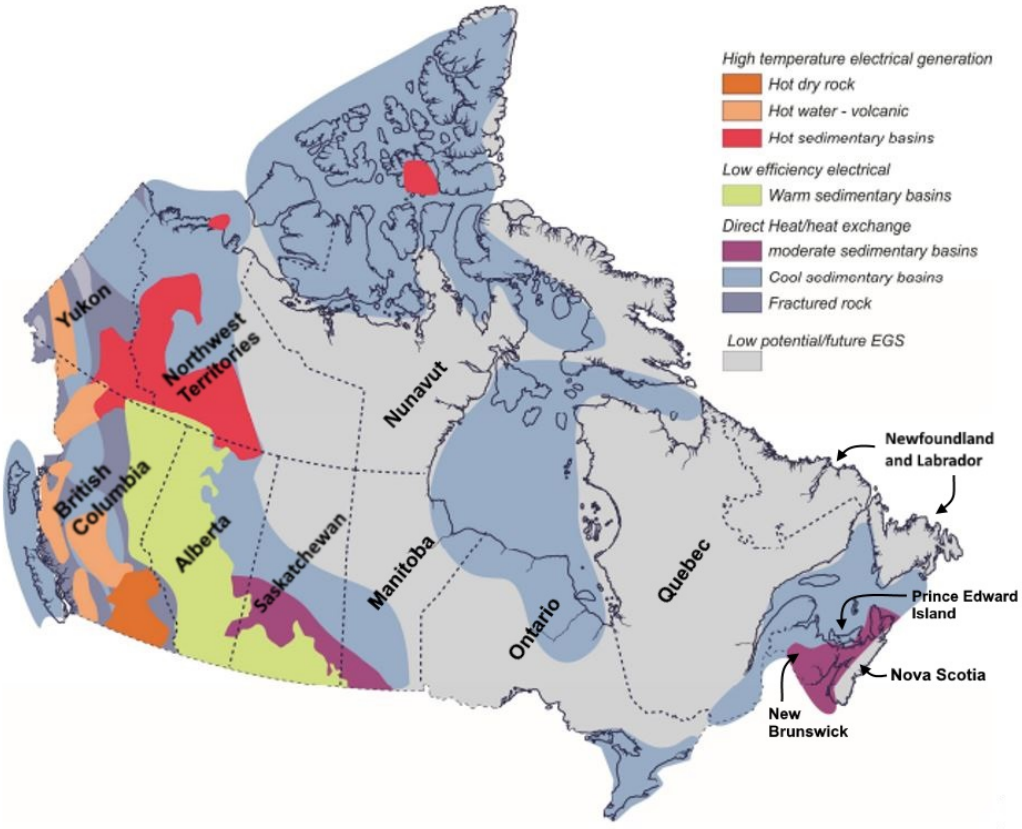

Figure 1: Map showing distribution of geothermal potential in Canada

[2] Grasby, Stephen E., et al, "Geothermal Energy Resource Potential of Canada," page IX, 2012.
[3] Natural Resources Canada: CanmetENERGY "Sector Profile,"2013.

The Canadian market poses several challenges to geothermal energy development. Firstly, there exists a dearth in early stage supportive policies and funding programs, both provincially and federally. In addition, several provincial jurisdictions have failed to develop regulatory frameworks for geothermal energy development. This creates an uncertain environment for investors and makes it difficult for developers to advance projects beyond the exploration phase.

In addition to policy challenges, the misconception that geothermal energy's sole value offering is power generation has hampered prospective development. In response, educational initiatives have been focused on refining the public's understanding of geothermal energy. One example is CanGEA's travelling Geothermal Energy Literacy Roadshow: "Geothermal 101" is a series of informational workshops piloted in Alberta that explain what geothermal energy is, how it is produced, what benefits it offers, and what type of projects could be developed in Alberta. The audience reached includes older adults, youth, Indigenous peoples and rural communities.

Despite challenges, recent developments engender hope for a changing policy landscape in Canada. A report tabled by the federal government's Standing Committee on Natural Resources named *geothermal* as a renewable energy topic that needs better data coverage.[4] In their response, the Government of Canada outlined their intention to establish a website that will provide a single-point-of-access to federal energy information, thereby simplifying access to Statistics Canada's energy-environment-economy data. In complement to this initiative, Statistics Canada is upgrading its national data collection to address data gaps related to renewable energy.

Further, the Government of Canada's signing of the Paris Agreement, its commitment to the United Nation's Sustainable Development Goals, and its renewed commitment to safeguarding the Arctic through the Arctic Environmental Protection Strategy (AEPS) indicate a political will at the federal level for cleaner energy extraction and production.

2. Provincial and Territorial Geothermal Landscapes

This section will examine each of the Canadian regions that have prospective or completed geothermal energy projects. Project benefits, relevant studies, and barriers will be explored, as well as recommendations for future development.

2.1 Canada's North

Canada's North refers to the country's three northern Territories: Yukon, Northwest Territories, and Nunavut. The benefits that geothermal energy could bring to the North are numerous. Firstly, the region is not connected to the North American electrical grid, leading to reliance on diesel for electricity generation and also for heating. As diesel is high in both cost and GHG emissions, geothermal offers a clean alternative for heat and power in northern communities. Additionally, food security is an issue in the region. Most food cannot be grown locally and must be imported at high cost. The application of geothermal heat to greenhouse agriculture is thereby even more meaningful in Canada's North than in warmer regions with longer growing seasons.

[4] House of Commons Canada, Standing Committee on Natural Resources, "Current State and Future of National Energy Data," 2018.

To address the issues outlined above, the Government of Canada has created several funding programs to promote alternative power production. One example is the *Indigenous Off-diesel Initiative*, a program created by Impact Canada to empower remote Indigenous communities and reduce their reliance on diesel.[5] Emblematic of the current state of Canada's geothermal industry, the initiative's website does not list geothermal alongside wind, solar, hydro, and biomass as local renewable energies that "can replace diesel, reduce the environmental and health impacts of diesel use, and create local jobs and economic opportunities for your community."[6] The absence is notable, as geothermal technology runs more efficiently at large temperature differentials, a condition which can be expected in Northern communities.[7] Moreover, many Canadian Indigenous communities have stated their support for geothermal development.

The economics of geothermal energy development in the North is worth further examination. The price of heating fuel and electricity in northern communities are, on average, five to ten times more expensive than the rest of Canada.[8] Further, the resources commonly used for heating and electricity, such as diesel and natural gas, are more carbon-intensive resulting in health and environmental impacts.[9] An economic evaluation of geothermal energy titled, "Geothermal Energy for Northern Canada: Is it Economical?" found that:

> …modeling of the available geothermal energy for northern Canadian communities shows that there is enough energy to heat northern communities at a competitive cost in the areas of Mackenzie Corridor and Yukon. Future work is required, however, to examine site-specific characteristics near communities to define better local potential.[10]

Although more research and exploration is necessary, early indicators point to substantial benefits as a result of further geothermal energy development in Canada's North.

2.1.1 Yukon

Yukon has employed the direct use of geothermal energy for several decades in the Takhini Hot Pools, operated near the capital city of Whitehorse. A vertical indoor aquaponics project, heated and cooled by geothermal waters, is also being developed by CanGEA member North Star Agriculture, near the Takhini Hot Pools. The company recently received its development permit and is planning the next steps towards providing Whitehorse residents with locally-raised, year-round food. In addition to food production, they also plan to use their small-scale aquaponics facility as a showcase for the benefits of geothermal heat and aquaponics.

The Yukon Geological Survey (YGS) published an informational document in January 2017 entitled *Geothermal Energy Yukon*.[11] Part of a wider YGS Educational Series, the document brings the public up-to-date on YGS's multi-faceted geothermal research work focused on

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[5] Impact Canada, "Indigenous Off-diesel Initiative," 2019.
[6] Ibid.
[7] Herfurth et. al, "Performance Optimization of ORC Power Plants," 2015.
[8] Majorowics, Jacek and Minea Vasile, "Shallow and deep geothermal energy potential in low heat flow/cold climate environment: northern Québec, Canada, case study," 2015.; Majorowicz, Jacek and Stephen E. Grasby, "Geothermal Energy for Northern Canada: Is it Economical?"
[9] National Energy Board, "Canada's Energy Future 2016: Update - Energy Supply and Demand Projections to 2040," 2016.
[10] Majorowicz, Jacek and Stephen E. Grasby, "Geothermal Energy for Northern Canada: Is it Economical?"
[11] Yukon Geological Survey, "Geothermal Energy Yukon," 2017.

understanding heat generation and ground temperature in the territory. The project is a collaborative effort among government geoscientists, universities, First Nations governments and geothermal consultants, and has included two Yukon-wide desktop studies and the drilling of two 500 metre temperature gradient wells.

This type of government publishing reflects the increased level of knowledge within Yukon's Department of Energy, Mines and Resources, as well as an increased political will to explore clean, renewable sources of electricity and heat in the region.

Yukon also has geothermal resource estimate data and maps available in the Canadian National Geothermal Database, hosted by CanGEA.

2.1.2 Nunavut

In June 2018, Nunavut completed a geothermal feasibility desktop study, with the results located in the Canadian National Geothermal Database, hosted by CanGEA. The objectives of the study included gathering existing data, identifying data gaps, and conducting a geothermal resource assessment based on the existing data.[12] The report concluded that Nunavut does not have geothermal resources that are fully characterized and ready for development, and two steps remain to understand the Territory's geothermal potential:

(1) Collecting additional data to characterize the subsurface thermal properties and geothermal gradients at the communities, and
(2) Finding solutions to overcome engineering challenges and opportunities that are related to permafrost, EGS reservoir development, and deep drilling and to potentially use hybrid solar thermal and geothermal systems.[13]

Qulliq Energy Corporation, the Territory's power authority, is currently seeking funding to continue the work. Aligning with the standards set out by the Canadian Geothermal Code for Public Reporting, this fieldwork will be used to present a finalized feasibility study.[14]

2.1.3 Northwest Territories

The Northwest Territories Geological Survey has expanded the scope of their 2017-22 strategic plan to assess energy resources, including geothermal energy, as a future source of electricity and heat. They are investigating the potential for electricity and district heating projects and intend to help support legislation tailored to the Northwest Territories' opportunities and needs.

2.2 British Columbia

The province of British Columbia boasts some of the highest quality geothermal resources available in Canada. Electricity and/or heat generation projects represent a path for rural and remote communities, to achieve energy security and independence.

[12] Qulliq Energy Corporation, "Nunavut Geothermal Feasibility Study," 2018.
[13] Ibid.
[14] Qulliq Energy Corporation, "Geothermal Energy," 2019.

There are currently two projects in development in British Columbia by CanGEA member Borealis GeoPower: The Canoe Reach project 30km south of Valemount and the Lakelse project 10km south of Terrace. The Canoe Reach project aims to develop a multi-phased GeoHeat Park where local businesses utilize geothermal heat, with power production slotted for the second phase of the project. The Lakelse project is also looking to develop a GeoHeat Park for local businesses, with a latter phase including a 15MW commercial power plant.

In 2018, the Government of British Columbia released a plan titled: CleanBC. The plan is aimed at reducing climate pollution, while creating more jobs and economic opportunities in a low-carbon economy. It also outlines the intention to transition the province to fully renewable energy and reduce 18.9 Mt of greenhouse gases by 2030.[15] CleanBC will "encourage investments in small-scale, community-owned energy generation from sources such as biomass, biogas, geothermal heat, … to offset community energy use."[16]

2.3 Alberta

Alberta is located in the Western Canada Sedimentary Basin and has areas of both high and low geothermal potential. Communities along the Rocky Mountains, such as Obed, appear to have some potential for geothermal power generation. As a result of its large oil and gas sector, Alberta is also home to world class drilling experts. There are excellent opportunities for synergy between the province's well-established oil and gas industry and geothermal energy development. However, the lack of a regulatory framework in Alberta impedes investment and leaves prospective developers in a milieu of uncertainty.

There are several other notable geothermal energy developments in Alberta. Among them, CanGEA member E3 Metals Corp (see Figure 2). is currently looking to utilize geothermal energy to decarbonize their petro-lithium extraction facility.[17] Another CanGEA member, the University of Alberta Geothermics Research Group has opened a Rock-Fluid Interaction Lab, open to geothermal developers with the goal of advancing understanding of Alberta and Canada's resources.

2.4 Saskatchewan

Saskatchewan is located at the eastern most reach of the Western Canada Sedimentary Basin and has moderate geothermal resources. Deep Earth Energy Production Corp. (DEEP) signed a Power Purchasing Agreement (PPA) with the Saskatchewan government in November 2018. The goal of DEEP's project is to become the first geothermal power production facility in Canada, providing geothermal power to residents in the town of Estevan and heat to a greenhouse facility. Drilling started days after receiving the PPA, and the first test well was completed in January 2019. The federal government has invested $25.6 million in the project under a federal renewable energy funding program; this represents a significant milestone for DEEP and the Canadian geothermal industry as a whole.[18] It is worth noting that the project's eligibility for renewable energy funding programs and tax incentives are a result of CanGEA's advocacy efforts.

[15] CleanBC, "Our Nature, Our Power, Our Future," 2019.
[16] Ibid.
[17] E3 Metals, "Projects: Alberta Lithium," 2018.
[18] Prime Minister's Office, "Prime Minister announces support for Canada's first geothermal power facility," 2019.

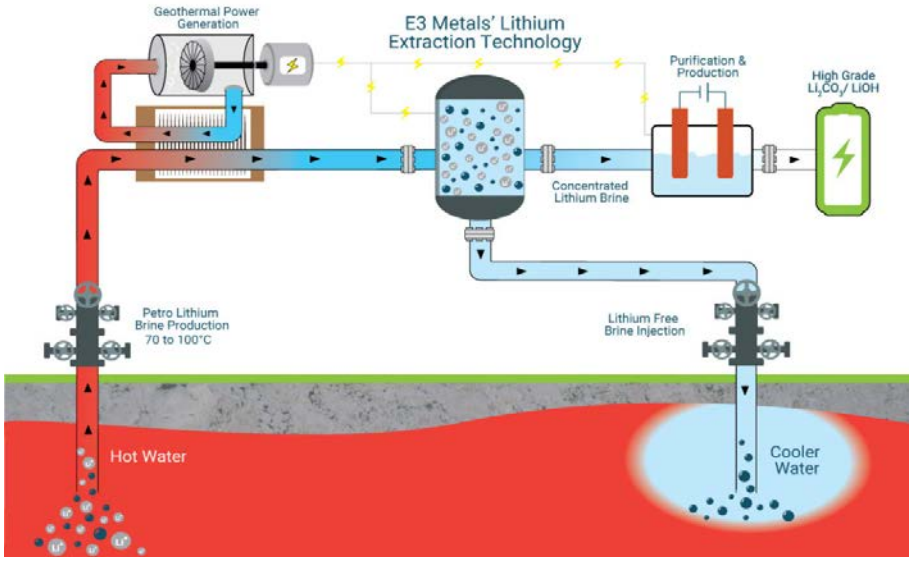

Figure 2: E3 Metals' Lithium Extraction Technology

2.5 The Maritimes

The Maritimes is a region of Eastern Canada consisting of the provinces of New Brunswick, Nova Scotia and Prince Edward Island. This region has moderate potential for geothermal heat projects using flooded and abandoned mines as a geothermal reservoir.

In the late 1980s, the town of Springhill, Nova Scotia, began heating and cooling portions of the Springhill Industrial Park using abandoned and flooded coal mine workings as a geothermal reservoir. More recently, the Cumberland Energy Authority began investigating how the geothermal resources at Springhill could be better utilized and have completed Phase 1 of a three-phase assessment for future development planning.[19] In its entirety, the assessment will cover current uses, available field data, energy and cost savings, GIS analysis, and a deep mine water exploration project.

In the summer of 2017, the Town of Sussex, New Brunswick, completed a technical feasibility study to determine the geothermal potential of the decommissioned Penobsquis Mine. The former potash mine is located 10 km Northeast of Sussex and was closed in 2016. Results from this study determined that the most favourable application would be a "district open loop geothermal system heating a 20-acre greenhouse (with supplemental boiler) and cooling 10 refrigeration warehouses for a 12-month period."[20] The capital investment for this project was estimated at C$11.3M. Among the businesses interested in the geothermal district heating system is a local floral greenhouse, Avon Valley Greenhouse, which is currently using wood to heat their 20-acre site. Benefits include low-cost heat, a reduction in GHG emissions, and the ability for the greenhouse to extend their growing season year-round.

[19] Cumberland Energy Authority, "Renewable Energy," 2019.
[20] Town of Sussex, "Final Report: Technical Feasibility Study of the Geothermal Capability of the Penobsquis Mine Site," 2018.

2.6 Manitoba and Ontario

These two provinces have low geothermal potential given their location in the Canadian Shield, which is "characterized by igneous and metamorphic rock composed of some of the oldest crustal rocks on Earth."[21] The age of the rock means radioactive decay, and concurrent heat generation, is minimal. Further, the strong conductivity of the rock leads to lowered geothermal gradients.

There remains an opportunity for Enhanced Geothermal Systems (EGS) in the Canadian Shield, however, this is a long-term prospect with little room for short term implications. These provinces do take advantage of the rock's conductivity by way of GeoExchange systems.

2.7 Quebec

Much like Canada's North, northern Quebec experiences exceptionally high diesel and fuel oil prices, heightening the value of geothermal energy's heat applications.[22] In 2017, the Institut National de la Recherche Scientifique (INRS) received funding from the United Nations Economic and Social Council (UNESCO) and Quebec's public electricity utility (Hydro-Quebec) to analyze and evaluate the potential for geothermal energy use in the St. Lawrence Lowlands (SLL) Sedimentary Basin. In the study, titled "Geothermal potential of the St. Lawrence Lowlands sedimentary basin from well log analysis," Nasr et al. targeted already established wells for oil and gas extraction. A summary of findings is provided below:

> Heat flux and temperature maps were prepared according to the described approach for the SLL basin. Analysis of these maps shows that temperatures of 80 °C are accessible at depths of 2500m in different areas of the basin. The maps additionally indicated that temperatures of 120 °C and 150 °C, considered for electric power production, are possible at a depth of 4000 m and 5000 m. The heat flow map suggests an average value of about 63 mW/m^2 for the SLL sedimentary basin. [23]

The values obtained in the 2017 study are higher than those reported in 2012 by Majorowicz and Minea, indicating more favourable geothermal potential than previously reported.[24] These discrepancies also highlight the need for additional exploration and research, (as noted also in Majorwicz and Minea's report summary).[25] A third document, published by Hydro-Quebec, is titled, "A Renewable Energy Option: Deep Geothermal Energy."[26] This document indicates that reservoir temperatures at a depth of 7 kilometres support the presence of high quality geothermal resources, although an EGS would be required to extract these resources. Although the capital cost of EGS is higher than the cost of geothermal development in other parts of Canada, technological advancement has made it increasingly more feasible from a financial perspective.

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[21] Grasby, Stephen E., et al, "Geothermal Energy Resource Potential of Canada," 2012. Geological Survey of Canada.
[22] Majorowicz and Minea, "Shallow and deep geothermal energy potential in low heat flow/cold climate environment: northern Québec, Canada, case study."
[23] Nasr, Maher., et. al, "Geothermal potential of the St. Lawrence Lowlands sedimentary basin from well log analysis." September 2018. Geothermics 75:1.
[24]Majorowicz and Minea, "Shallow and deep geothermal energy potential in low heat flow/cold climate environment: northern Québec, Canada, case study."
[25] Ibid.
[26] Hydro-Quebec, "A Renewable Energy Option: Deep Geothermal Energy," 2016.

3. Federal Considerations

Data collection and accessibility remain issues at the national level. While other countries possess geothermal prospector tools, Canada lags behind in this respect. CanGEA hosts the Canadian National Geothermal Database; however, added capacity for geothermal energy data collection agencies such as the Geological Survey of Canada and Natural Resources Canada would facilitate more robust data repositories. Mapping has been done in Alberta, British Columbia, Yukon and Nunavut, but feasibility studies are outstanding for many other Canadian regions. As noted, geothermal energy was also cited in a report published by the Standing Committee on Natural Resources as a renewable energy topic that needs better data coverage.[27]

Lack of federal funding and tax incentives is a second barrier to the development of geothermal energy in Canada. Tax programs currently on offer include the Canadian Renewable and Conservation Expenses (CRCE) tax relief program and the Scientific Research and Experimental Development tax incentive program. CanGEA has obtained a technical interpretation from the Canadian Revenue Agency (CRA) as it pertains to geothermal developers and the CRCE incentive program. This guides developers' understanding of the program and how best to engage with it. CanGEA also organized a seminar in September 2018 in which representatives from the CRA and Natural Resources Canada delivered short presentations on each tax program. The Government of Canada's Fall Economic Statement, released in November 2018, also introduced new provisions pertaining to Capital Cost Allowance. These modifications created an accelerated investment incentive, allowing businesses to deduct the cost of their investments more quickly. The goal is to make Canadian projects more attractive to investors.

4. Concluding Summary

There are several reasons for optimism regarding the future of Canadian geothermal energy. Public sentiment appears to be increasing, projects are moving forward, and the federal government has enhanced its toolkit of financial incentives.

However, more work remains in terms of closing the regulatory gaps at both provincial and federal levels. Opportunities for public outreach and education remain, as well as opportunities to further collaboration between all renewable energy types in order to establish efficient and complementary energy mixes.

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