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Geothermal Industry Development in Canada - 2020 Country Update

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ABSTRACT

In Canada, geothermal energy is used for space conditioning via ground source heat pumps, and for bathing and swimming in naturally occurring hot springs and geothermal natatoriums. Geothermal heat pumps have been deployed across the country and have seen significant growth over the last decade. More than 150 thermal springs are known to exist in Western Canada but only 48 have sufficient data for characterization. 12 have been developed into commercial hot spring resorts and spas that account for the only geothermal energy direct use in Canada with an installed capacity of roughly 8.8 MWt.

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 and territorial 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.

However, the general sentiment in Canada towards geothermal energy development has improved in recent years as a result of a growing appetite for clean energy sources, a rising cost of carbon and CanGEA's continued public outreach efforts. More funding avenues have been developed at the Federal government level, as well as new tax incentives made available to geothermal developers. There are several electricity generation projects currently underway, at various levels of progress.

Current industry initiatives include maintaining the Canadian National Geothermal Database, provincial/territorial geothermal favourability mapping, energy literacy initiatives and various advocating efforts on the part of the Canadian Geothermal Energy Association to build provincial and federal policy support for the geothermal industry.

1. INTRODUCTION

Canada is still the only continental North American country on the ring of fire to not produce electricity from its geothermal resources. Alongside hot sedimentary basins in the jurisdictions of Alberta, Saskatchewan, and Northwest Territories, there are high-temperature hydrothermal resources in British Columbia and the Yukon Territories. In total, it is estimated that there are as much as 5,000 MWe of economically feasible geothermal potential in Western Canada using currently available technology. An additional 10,000 MWe or more may be available in deep geothermal resources for future exploitation using enhanced geothermal systems. (Ghomshei 2010) Despite the potential of Canada's geothermal energy, none of it has been realized for electricity generation. The utilization of geothermal energy in Canada has been limited to ground source heat pumps and naturally occurring hot springs and geothermal natatoriums.

However, Canada's geothermal energy industry has made some significant strides since the last World Geothermal Congress. The Nation's energy policy has been in a state of continuous evolution, becoming increasingly inclusive of clean energy alternatives and the geothermal energy type. In fact, geothermal energy has experienced a fair amount of political support in recent years at the federal, provincial and territorial levels. This is evidenced by new tax relief programs, funding opportunities, and support for new feasibility studies. Four geothermal feasibility studies have been conducted, covering the provinces of British Columbia and Alberta, as well as the territories of Yukon and Nunavut.

In 2019, Prime Minister Justin Trudeau announced an unprecedented C$25.6 million investment in the development of a geothermal electricity plant in Saskatchewan. The newly-elected conservative government in the province of Alberta also expressed support for geothermal energy development in its campaign platform. Further, the Yukon Geological Survey (YGS) published an informational document in January 2017 entitled *Geothermal Energy Yukon* (Yukon Geological Survey 2017). The project is a collaborative effort between 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 growing wave of political support has fostered industry growth, and currently, there are over 14 geothermal energy projects under development in Canada.

The Canadian Geothermal Energy Association (CanGEA) was founded and incorporated in 2007 and earned the right to continue its mandate in 2014 under the new *Canadian Not for Profit Corporations Act*. CanGEA is distinct from previous geothermal industry efforts in the 1980's-mid 2000s in that CanGEA's main activity is political advocacy with a truly pan-Canada effort on the direct use of geothermal heat and geothermal electricity production. CanGEA complements the activities of the Canadian GeoExchange Coalition, which represents the ground source heat pump industry. Additionally, CanGEA works beside other Canadian renewable energy advocacy groups in Canada to reach a common goal of a low carbon Canada, and Geothermal Canada, which serves the academic and research community.

2. GEOLOGY BACKGROUND

Geothermal energy is an accessible resource across Canada. However, for the purpose of electrical generation, high-temperature geothermal resources are restricted to a corridor in western Canada that has been influenced by Mesozoic/Cenozoic tectonic and orogenic events.

2.1 Volcanic Geology

Along the western margin of British Columbia and Yukon Territory, in the Canadian Cordillera, two distinct volcanic regions with Quaternary eruptive episodes constitute the areas of greatest interest to geothermal electricity production.

2.1.1 Garibaldi Volcanic Belt

The Garibaldi volcanic belt in southwestern BC is the product of an active subductive margin between the Juan de Fuca and Pacific plates. The result is a belt of stratovolcanoes that trend parallel to this tectonic boundary. Within this belt lie several prominent stratovolcanoes, amongst them Mount Meager, Mount Cayley and Mount Silverthrone, which have been uniquely identified as areas of interest for geothermal electricity (Jessop et al. 1991). There is an ongoing regional assessment of the Garibaldi Volcanic Belt's geothermal energy potential (Grasby 2018).

2.1.2 Northern Cordilleran Volcanic Province

In northwestern BC and encompassing most of the Yukon Territory lies the northern Cordilleran volcanic province (Edwards & Russell, 2000), a product of continental rifting from within the North American plate. Resulting in a series of basaltic shield volcanoes, which currently constitute the most active volcanic region of Canada (Geological Survey of Canada 2008). Mount Edziza and Hoodoo Mountain are particularly regarded as areas of geothermal potential in this volcanic region (Jessop et al., 1991). In 2016, a study was initiated by the Yukon Geological Survey to reduce the geothermal exploration risk by providing baseline geothermal data and identifying target areas with higher heat flow (Fraser et al. 2019).

2.2 Sedimentary Geology

The Western Canada Sedimentary Basin (WCSB) is a vast sedimentary basin, which consists of a maximum of 6 km of stratigraphy in its western margin, thinning to 0 m at the eastern basin edge (Wright et al. 1994). The depositional history is protracted, and the diversity of sedimentary units reflects this history. Where the sediments are deepest, a moderate temperature geothermal resource is found. Conservatively assuming that 1% of the water in the WCSB could be considered a geothermal resource, then the geothermal reserves in the WCSB would be 4-5 times higher than the thermal equivalent of the remaining oil reserves (Jessop et al. 1991). With the applications of geothermal binary technologies, there is potential to harness Hot Sedimentary Aquifer (HSA) resources for electricity generation.

3. GEOTHERMAL RESOURCES, POTENTIAL, AND UTILIZATION

Canada boasts a substantial geothermal resource with some level of geothermal development possible throughout the country. Although high-temperature electricity production and low-temperature direct use opportunities exist across the nation, there remains a limited development of the Canadian geothermal resource to date. A 2012 report by the Geological Survey of Canada concluded that Canada "has enormous geothermal energy resources that could supply the country with a renewable and clean source of electricity" but that sufficient data to quantify the geothermal resource existed for only 40% of the Canadian landmass (Grasby et al. 2012). This is likely a result of a 30-year hiatus in federal government funding of geothermal science. Since 2015, there have been multiple studies conducted to amplify data coverage throughout Canada. Particularly, CanGEA spearheaded feasibility studies in the Yukon, Alberta, and British Columbia. A detailed analysis of each respective region's geothermal energy potential was produced and contributed towards the Canadian National Geothermal Energy Database (CNGD) (CanGEA 2019). Coupled with advocacy efforts, resulting in policy shifts, the compiled studies have mobilized multiple geothermal energy actors across Canada. Currently, there are 7 electricity generation projects in development in Alberta, Saskatchewan, and British Columbia.

3.1 High-Temperature Hydrothermal Resources: Electricity Production

Canada is the only large country along the ring of fire that has yet to develop any geothermal electricity capacity, even though its southern neighbour, the United States, ranks 1st in total installed capacity. The United States has almost exclusively developed its 3.6 GWe of installed capacity, in addition to 21 installed district-heating systems.

There are several projects that have gained notable traction in Canada. CanGEA member, Borealis GeoPower, received funding to advance their geothermal *Sustainville GeoPark* forward. Projects across other provinces and territories, such as the Yukon and Nunavut, have begun moving forward. There is growing interest in eastern Canada as well. CanGEA member, Cumberland Energy Authority recently released a Request for Proposal (RFP) for a geothermal business park and district energy system. A research project has been announced in Northern Quebec to determine the feasibility of geothermal energy for remote communities (Concordia University 2019). The current climate of the industry and its projects will be further investigated in the "Current Industry Initiatives" section.

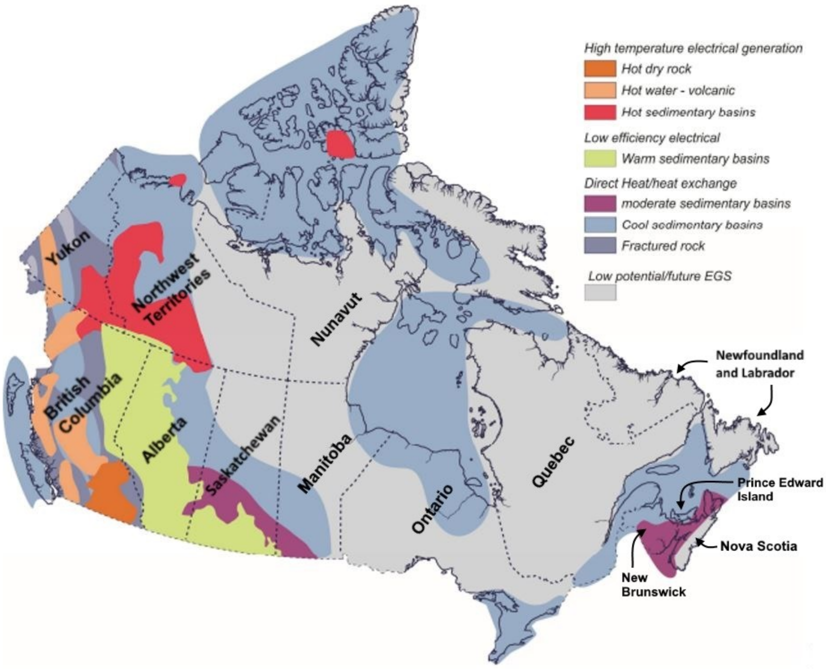

Figure 1: Canadian geothermal resource potential (Grasby et al., 2012)

The Canadian Cordillera stretches north from British Columbia to the Yukon and offers the greatest potential for high-temperature geothermal resources (>150°C) in Canada. There are several volcanic structures present but those older than roughly 10 million years have likely lost most of their residual heat. Tertiary volcanism is restricted to the Garibaldi Belt, which is the continuation of the Cascade Volcanic Belt, the Anaheim Belt, and the Stikine Belt. The tertiary intrusive rocks present have high geothermal gradients as a result of radiogenic elements within the rocks. There are also over 157 identified hot springs in the Canadian Cordillera and hot sedimentary basins, which provide a good indicator of the presence of a geothermal resource. In fact, it was the presence of a hot spring at Mt Meager in the Garibaldi Belt that led to the discovery of a major geothermal resource at Meager Mountain that has been investigated for geothermal electricity development. HSA resources are found in the WCSB that stretches from British Columbia into Alberta and Saskatchewan as well as others in the western portions of the Northwest Territories, eastern Yukon, and in localized areas of the Mackenzie corridor, the Sverdrup Basin, and the Foreland basins (Grasby et al. 2012). A recent study analyzed the WCSB and found several areas with the core data necessary to determine geothermal energy viable. Aquifers in areas such as Horn River, Clarke Lake, Prophet River, and Jedney have a combined electricity capacity of 107.3 MW (Palmer-Wilson et al. 2018).

It is estimated that over 5,000 MWe is available from shallow geothermal resources, including hot sedimentary aquifers, using current technology with an additional 10,000 MWe or more available in deep geothermal resources for future exploitation using enhanced geothermal systems (Ghomshei 2010). Although advocacy efforts have found success in steering Canada's geothermal industry forward, factors such as policy support and the resulting financing climate remain a hurdle for electricity projects to move forward at a steady pace. Further, of the 14 geothermal energy projects under development in Canada, 9 have an element of electricity generation (see Figure 2).

Project	Developer	Province/Territory	Project Status
Canoe Reach	Borealis GeoPower	British Columbia	Fieldwork in progress, one well drilled
Fort Liard	Borealis GeoPower	Northwest Territories	FEED Complete
Lakelse Lake	GeoPower	British Columbia	Fieldwork in progress
Pebble Creek	Geotec Renewable Energy	British Columbia	Permit
Swan Hills	Razor Energy, University of Alberta	Alberta	Demonstration Project, Under Construction
Ross River	Kaska First Nations	Yukon Territory	Fieldwork in progress
Estevan	Deep Earth Energy Production Corp.	Saskatchewan	Flow testing program of the geothermal resource, one well drilled
Condor	Eavor	Alberta	Demonstration project, drilling complete
Greenview County	Terrapin	Alberta	Fieldwork in progress

Figure 2: Geothermal electricity projects in Canada

3.2 Low-Temperature Resources: Direct Use Applications and Geothermal Heat Pumps

There are substantially more opportunities with low-temperature resources in Canada, particularly direct use applications and the use of geothermal heat pumps. Direct utilization of geothermal heat is currently limited to commercial hot springs. As mentioned earlier, 157 hot springs have been identified in British Columbia, Alberta, Yukon Territory, and the Northwest Territories. Sufficient data exist to characterize 48 hot springs, which have an estimated heat output of 250 MWt. It should be noted that hot springs tend to vary in heat flow annually based on a variety of factors and due to the lack of up-to-date data; there is a large margin of error in the estimated heat output.

Currently, 13 naturally occurring hot springs in Western Canada have been commercialized and developed into bathing, swimming, and balneological facilities and are listed in Table 1.

Table 1: Hot springs of Western Canada

Name	Province	Flow rate (L/s)	Springs temperature (°C)	Pool outlet temperature (°C)	Capacity (kW_t)
Banff Upper	AB	14.9	47	38	563
Miette	AB	15.3	54	37	1092
Ainsworth	BC	6.9	47	32	435
Fairmont	BC	20.9	46	44	176
Halycon	BC	3.5	54	32	323
Harrison	BC	26.1	40	28	1,315
Liard	BC	30.0	52	30*	2,772
Nakusp	BC	1.2	57	30	136
Mount Layton (Lakelse)	BC	9.9	41	30	457
Radium	BC	28	40	32	941
Skookumchuck (St. Agnes)	BC	3.2	35	30	67
Takhini	YT	5.7	40	35	120
Temple Gardens Mineral Spa	SK	5.7	46	30	383
				Total capacity (kW_t)	8,780

Abbreviations: AB, Alberta; BC, British Columbia; SK, Saskatchewan; YT, Yukon. *Assumed temperature as water flows in swamps.

4. GEOTHERMAL POLICY DEVELOPMENT

Canada lacks geothermal-specific policies, legislation, and generation targets at the federal level. However, in recent years there has been an uptick in opportunities for renewable energy types, including geothermal energy. While Canada's geothermal resources are most abundant in Western Canada, particularly in British Columbia, Yukon Territory, Northwest Territories, Alberta, and Saskatchewan - only British Columbia, Saskatchewan and Nova Scotia have provincial frameworks to govern the development of their geothermal resources.

The following section will elaborate on federal government policy developments, and also highlight regional developments that have occurred in recent years.

4.1 Federal - Policy Development

Since 2015, advocacy efforts have been met with several notable changes at the federal level. In 2017, a bill was passed that enhanced tax relief support for project development expenses through the Canadian Renewable Conservation Expense (CRCE) program for clean energy developers, where both geothermal heat and electricity developers are eligible (Natural Resources Canada 2018a). In response to the tax changes, CanGEA worked with the Canadian Revenue Agency to develop a technical interpretation of the existing guide for geothermal developers. CanGEA also worked with the government to host an informational event on the different tax relief programs available to developers.

The federal government's 2018 Fall Economic Statement contained provisions that allow for clean energy equipment expenses to be expensed fully in the first year, up until 2024 (Natural Resources Canada 2018a). With this extension, Geothermal energy's eligibility under the accelerated capital cost allowance (ACCA) was also announced. Additionally, in Fall of 2018, new enhanced tax expense measures for clean energy equipment were also announced. Now, under Class 43.2 eligible clean energy equipment, such as geothermal turbines, can be expensed fully in the first year up until 2024 (Natural Resources Canada 2018b).

Natural Resources Canada (NRCan) has three distinct funding programs that have supported geothermal energy projects and technology in recent years. The Energy Innovation Program (EIP) supports reducing emissions, including GHGs, through research, development and demonstration of clean energy technologies. The Emerging Renewable Electricity Program (ERPP) mitigates the risk of emerging renewable electricity projects, allowing emerging renewables to play a larger role in Canada's electricity supply mix. Lastly, the Clean Growth Program invests in clean technology research and development and demonstrations projects in energy, mining, and forestry.

The newly established Canada Infrastructure Bank (CIB) is another potential funding source for developers. The CIB has $5B for green infrastructure projects, including those that reduce greenhouse gas emissions and promote renewable electricity. Although no current geothermal developers have projects of the scale targeted by the CIB, this funding vehicle offers financing for higher-risk projects that are deemed as having long-term sustainable benefits to communities and could be utilized in the future.

In June 2018, the federal government announced that every dollar earned from expanding the state-owned Trans Mountain Pipeline will be invested in clean energy projects. The Government estimated tax revenues from the bitumen-carrying pipeline could generate as much as $500M annually following project completion. This is an additional funding source that could support geothermal energy projects in the future.

CanGEA has also taken part in several other advocacy efforts including federal committee and departmental budget submissions. Most notably, CanGEA participated in a federal committee inquiry into the "Current State and Future of Energy Data in Canada," where we advocated for the need for increased geothermal feasibility studies throughout Canada. In response to CanGEA and other Associations efforts, the federal committee tabled recommendations to the government that included the establishment of a federal repository for energy data in Canada, and geothermal energy was recognized as a resource in need of increased data coverage in Canada (Maloney 2018).

4.2 British Columbia - Policy Development

In 2017, the Government of British Columbia (BC) initiated a study into the need and viability of the Site C 1,100 MW hydroelectricity project. Considering the potential environmental impacts of the large project, the implications with the flooding of traditional Indigenous hunting areas, and the number of other viable renewable energy alternatives, such as geothermal energy, CanGEA participated as a key player in the inquiry. As a result of CanGEA's participation, geothermal energy was added to the Commission's Alternative Energy Portfolio, which was put forward as a viable alternative solution to Site C, and one that could provide similar benefits to ratepayers with an equal or lower total cost (British Columbia Utilities Commission 2017). BC also recently updated their clean energy strategy with a new plan called CleanBC. The goal of CleanBC is to reduce emissions in three key areas: building, industry and transportation (CleanBC 2019).

In 2018, the BC government conducted a review on geothermal energy royalties. CanGEA submitted feedback to this review, with the key take away being that projects should be subject to a 10- year royalty holiday and the royalty rate should be equal to other renewable energy rates within the province.

In 2019, CanGEA registered as an intervener in the British Columbia Utilities Commission's Indigenous Utilities Regulation Inquiry. In addition to giving oral testimony, and responding to Information Requests from other participants, CanGEA developed 2 written submissions that provided evidence relating to indigenous- and municipally-owned geothermal utilities. CanGEA also registered as an intervener in the British Utilities Commission's Municipal Energy Utilities Regulation Inquiry, developing a written submission to inform the Commission regarding municipal applications of geothermal energy, including case studies of municipally-owned geothermal district heating projects.

4.3 Saskatchewan - Policy Development

In 2018, Saskatchewan developed a regulatory framework for geothermal energy projects. The Government of Saskatchewan has taken an approach of fitting geothermal energy development into existing oil and gas regulations and directives due to their resources being mostly HSA systems; the same systems that are utilized to extract oil and gas.

4.4 Alberta - Policy Development

In Alberta, no regulatory framework has been developed. However, the Government elected in April 2019 expressed support for geothermal energy in their campaign platform, and CanGEA has continued to advocate for a framework on behalf of the industry.

In 2019, CanGEA registered as an intervener in the Alberta Utilities Commission's Distribution System Inquiry. CanGEA's submission helped inform the Commission on geothermal energy and its bearing on Alberta's future energy mix and distribution system design. Emerging technologies, geothermal resource applications, policy conditions, and economic feasibility were explored.

4.5 Northwest Territories - Policy Development

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.

5.0 CURRENT INDUSTRY INITIATIVES

5.1 British Columbia - Industry

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.

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 electricity production slotted for the second phase of the project. The Lakelse project is also considering the development of a GeoHeat Park for local businesses, with a latter phase including a commercial electricity plant.

5.2 Saskatchewan - Industry

Saskatchewan is located at the easternmost reach of the Western Canada Sedimentary Basin and has moderate geothermal resources. A geothermal developer in Estevan signed an Electricity Purchasing Agreement with the Government of Saskatchewan in November 2018. The Estevan project hopes to become the first geothermal electricity production facility in Canada, providing 5MW of electricity to the grid, and heat to a greenhouse facility.

5.3 Alberta - Industry

The province of Alberta is well-known as the cornerstone of Canada's petroleum sector. Petroleum extraction processes often bring geothermal waters to the surface alongside oil and gas. This by-product of conventional oil and gas production is called "co-produced" fluid, and with the application of binary geothermal technology, it can be harnessed for on-site electricity generation.

There are two demonstration projects currently underway in Alberta that employ geothermal co-production. Firstly, an Alberta Innovates-funded project in the Swan Hills oil field is striving to produce 3-5MW of electricity with co-produced fluids. Leveraging existing infrastructure to generate green electricity and heat helps meet the facility's operational needs, and exemplifies how petroleum resources and geothermal resources can be developed in a complementary way. Similarly, CanGEA member E3 Metals Corp is considering utilizing geothermal energy to decarbonize their petro-lithium extraction facility.

Further to these co-production projects, there is a geothermal energy project currently being advanced by an Albertan developer in Greenview County. The project will use geothermal energy to generate 5MW of clean, baseload electricity, as well as heat. The developer aims to provide heat and electricity to a planned industrial park in Greenview County. This will be Alberta's first large scale geothermal energy facility. Additionally, a separate Albertan developer is constructing a closed-loop geothermal demonstration facility near the Town of Condor. The innovative approach taken by this developer makes its pilot project the first of its kind.

Other initiatives have included a geothermal feasibility study, led by CanGEA, for an Alberta First Nation interested in developing its geothermal resources, and a CanGEA published study that examined all existing wells within Alberta, filtering them by temperature in order to assess different geothermal applications.

5.4 Canada's North - Industry

5.4.1 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* (Yukon Geological Survey 2017). The project is a collaborative effort between government geoscientists, universities, First Nations governments and geothermal consultants, and has included two Yukon-wide desktop studies and the drilling of two 500 meter temperature gradient wells.

5.4.2 Nunavut

As a part of CanGEA's outreach activities, we regularly engage with governments and government entities throughout Canada; a recent example being the Qulliq Energy Corporation (QEC), which is Nunavut's arms-length, utility authority. In 2018, QEC completed a desktop feasibility study, which can be found on the CNGD, to identify potential geothermal resources to help offset the use of diesel for electricity and heat in the isolated communities of Nunavut. Prior to the study, CanGEA worked with the QEC to help design the parameters of the study, including the requirement to utilize the Canadian Geothermal Code for Public Reporting. The QEC is now a CanGEA member and CanGEA continues to work with the QEC on their geothermal file. Most recently, QEC is seeking funding to initiate a phase 2 feasibility study (Qulliq Energy Corporation 2018).

5.5 Eastern Canada - Industry

5.5.1 Nova Scotia

In 2019, CanGEA member, the Cumberland Energy Authority announced an RFP for a geothermal business park that utilizes abandoned mine water. The project is based in Springhill and will modernize the geothermal system now in place. Currently, the Cumberland Energy Authority is working with a local engineering firm to draft a concept design (Cumberland Energy Authority 2019).

5.5.2 New Brunswick

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" (Town of Sussex 2018). 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.

6. CURRENT CANGEA INITIATIVES

Numerous of CanGEA's policy advocacy efforts have been highlighted in other sections of this paper. These include submissions to various Utilities Commission Inquiries, public engagements, a royalty review, and federal committee and departmental budget submissions.

Another key pillar of CanGEA's operational mandate is public awareness and education. The Association has received government support in order to bolster these educational efforts. CanGEA spearheaded two important initiatives in order to help investors and communities better understand the potential of geothermal energy and its applications, described below.

Firstly, CanGEA developed a 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. This initiative was in response to limited public knowledge regarding geothermal energy and the audience reached includes older adults, youth, Indigenous peoples and rural communities. Over 1,500 people attended the Geothermal 101 sessions during the pilot.

Secondly, CanGEA is creating a guide to development for geothermal energy projects in Alberta. This will prove a valuable resource for future developers and for communities interested in harnessing their geothermal resources.

Lastly, CanGEA collaborates with entities such as the University of Alberta and the Geothermal Resources Council in industry events where relevant actors gather to perform business development activities such as networking, marketing, and information gathering. The University of Alberta will be hosting the Geothermal Systems in Sedimentary Basins Conference in Fall of 2020.

7. CONCLUSION

Geothermal energy development in Canada is beginning to move forward at a quicker pace. With improved tax incentives and increased funding opportunities at the federal level, CanGEA and Canada's geothermal industry are beginning to see the fruit of ongoing advocacy efforts. Most of the remaining regulatory and policy changes remain at the provincial and territorial level. momentum in the industry continues to build, CanGEA expects to make great strides in the coming years towards creating a favourable ecosystem for geothermal development across Canada. Canada has a wealth of natural resources, including geothermal resources, and with CanGEA acting as a catalyst for policy changes and awareness, we are confident that our geothermal energy industry will flourish.

REFERENCES

Alberta Strong and Free. 2019. United Conservative Association. [accessed 2019 July 31]. https://www.albertastrongandfree.ca/wp-content/uploads/2019/03/Getting-Alberta-Back-to-Work_UCP2019Platform.pdf.

British Columbia Hydro and Electricity Authority – British Columbia Utilities Commission Inquiry Respecting Site C – Project No. 1598922. 2017. British Columbia Utilities Commission. [accessed 2019 July 31]. https://www.bcuc.com/Documents/wp-content/10/00550_A-22_Alternative-Portfolio.pdf.

CANADIAN NATIONAL GEOTHERMAL DATABASE & PROVINCIAL RESOURCE ESTIMATE MAPS: BRITISH COLUMBIA. 2019. Calgary (AB): CanGEA; [updated 2015; Accessed 2019 July 31]. https://www.cangea.ca/britishcolumbiageothermal.html.

Class 43.1, Class 43.2 and CRCE Presentation to Canadian Solar Industries Association. 2018b. Natural Resources Canada. [accessed 2018 July 31]. https://solarcanadaconference.ca/wp-content/uploads/2018/07/Federal-Accelerated-Capital-Cost-Allowance_Michel-Francoeur.pdf.

CleanBC. 2019. (BC): Government of British Columbia. [accessed 2019 July 31]. https://cleanbc.gov.bc.ca/.

Concordia partnership explores geothermal possibilities in northern Quebec. 2019. Edmonton (AB): Concordia University; [updated 2019 June 12; accessed 2019 July 31]. https://www.concordia.ca/news/stories/2019/06/12/concordia-partnership-explores-geothermal-possibilities-in-northern-quebec.html.

Edwards, B., and Russell, J. 2000. Distribution, Nature, and Origin of Neocene-Quaternary Magmatism in the Northern Cordilleran Volcanic Province. GSA Bulletin. [accessed 2019 July 31]; 131(7-8): 1280-1295. https://pubs.geoscienceworld.org/gsabulletin.

Fraser, T., Colpron, M. and Relf, C. 2019. Evaluating geothermal potential in Yukon through temperature gradient drilling. In: Yukon Exploration and Geology 2018, K.E. MacFarlane (ed.). Yukon Geological Survey [accessed 2019 July 31]; 75–90Minewater Geothermal Business Park Concept Design Underway. 2019. Cumberland (NS): Cumberland Energy Authority; [updated 2019 July 25; Accessed July 31]. https://www.cumberlandnewsnow.com/news/local/concept-design-for-springhill-geothermal-business-park-underway-336905/.

Ghomshei, M. 2010. New Frontiers in Geothermal Energy: A Presentation at the Canadian Geothermal Energy Association Annual Conference 2010. Vancouver (BC).

Grasby, S.E., Allen, D.M., Bell, S., Chen, Z., Ferguson, G., Jessop, A., Kelman, M., Ko, M., Majorowicz, J., Moore, M., Raymond, J., and Therrien, R., 2012. Geothermal Energy Resource Potential of Canada Geological Survey of Canada. Open File 6914. [accessed 2019 July 31]; 10-322. doi:10.4095/291488.

Garibaldi Geothermal Volcanic Belt Assessment Project. 2018. (BC): Grasby, S. [accessed 2019 July 31]. http://www.geosciencebc.com/projects/2018-004/.

Geothermal Energy. 2018. Qulliq Energy Corporation. [accessed 2019 July 31]. https://www.qec.nu.ca/electricity-nunavut/renewable-energy/geothermal-energy.

Geothermal Feasibility Study. 2018. Town of Sussex. [accessed 2019 July 31]. https://sussex.ca/documents/geothermal-feasibility-study.

Geothermal Energy Yukon. 2017. Yukon Geological Survey. [accessed 2019 July 31] http://data.geology.gov.yk.ca/Reference/78530.

Jessop, A., Ghomshei, M., and Drury, M. 1991. Geothermal Energy in Canada, Geothermics, [accessed 2019 July 31]; 369-385.

Maloney, J. 2018. RETHINKING CANADA'S ENERGY INFORMATION SYSTEM: COLLABORATIVE MODELS IN A DATA-DRIVEN ECONOMY. [accessed 2018 July 31]. https://www.ourcommons.ca/Content/Committee/421/RNNR/Reports/RP10034978/rnnrrp10/rnnrrp10-e.pdf.

Palmer-Wilson, K., Banks, J., Walsh, W., Robertson, B., 2018. Sedimentary basin geothermal favourability mapping and electricity generation assessments. Renewable Energy [accessed 2019 July 31]; 127: 1087-1100. https://doi.org/10.1016/j.renene.2018.04.078.

Raymond, J., Malo, M., Tanguay, D., Grasby, S., and Bakhteyar, F. 2014. Direct Utilization of Geothermal Energy from Coast to Coast: a Review of Current Applications and Research in Canada. Proceedings of the World Geothermal Congress 2015, Melbourne (AU): International Geothermal Energy Association.

Stikine Volcanic Belt. 2008. Geological Survey of Canada. [accessed 2019, July 31]. http://gsc.nrcan.gc.ca/volcanoes/cat/belt_stikine_e.php.

Tax Savings for Industry. 2018a. Natural Resources Canada. [accessed 2018 July 31]. https://www.nrcan.gc.ca/science-data/funding-partnerships/funding-opportunities/funding-grants-incentives/tax-savings-industry/5147.

THE CANADIAN GEOTHERMAL CODE FOR PUBLIC REPORTING. 2010. Calgary (AB): CanGEA; [updated 2010; cited 2019 July 31]. https://www.cangea.ca/geothermal-code-for-public-reporting.html.

Wright, G., McMechan, M., and Potter, D. 1994. Atlas of The Western Canada Sedimentary Basin. Chapter 3, Structure and Architecture of the Western Canada Sedimentary Basin.

STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (Solar, Biomass, Wind)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2014	0		35000		80403		14273		16914		146590	
Under construction in December 2014												
Funds committed, but not yet under construction in December 2014												
Estimated total projected use by 2020												

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2019 (OTHER THAN HEAT PUMPS)

Locality	Type[1)]	Maximum Utilization					Capacity[3)] (MWt)	Annual Utilization		
		Flow Rate (kg/s)	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow (kg/s)	Energy[4)] (TJ/yr)	Capacity Factor5)
			Inlet	Outlet	Inlet	Outlet				
Banff Upper	B	14.9	47	38			0.561			
Miette	B	15.3	54	37			1.088			
Ainsworth	B	6.9	47	32			0.433			
Fairmont	B	20.9	46	44			0.175			
Halycon	B	3.5	54	32			0.322			
Harrison	B	26.1	40	28			1.310			
Liard	B	30	52	30			2.761			
Nakusp	B	1.2	57	30			0.136			
Mount Layton (Lakelse)	B	9.9	41	30			0.456			
Radium	B	28	40	32			0.937			
Skookumchuck (St. Ag	B	3.2	35	30			0.067			
Takhini	B	5.7	40	35			0.119			
Temple Gardens Miner	B	5.7	46	30			0.382			
TOTAL							8.747			

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2019

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating[4)]			
District Heating [4)]			
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying[5)]			
Industrial Process Heat[6)]			
Snow Melting			
Bathing and Swimming[7)]	8.78	277	
Other Uses (specify)			
Subtotal			
Geothermal Heat Pumps	1,822.5	14,235	
TOTAL	1,831.28	14,512	

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits
6) Excludes agricultural drying and dehydration ted
7) Includes balneology

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (RESTRICTED TO PERSONNEL WITH UNIVERSITY DEGREES)

(1) Government (4) Paid Foreign Consultants
(2) Public Utilities (5) Contributed Through Foreign Aid Programs
(3) Universities (6) Private Industry

Year	Professional Person-Years of Effort					
	-1	-2	-3	-4	-5	-6
2015	Unknown	Unknown	Unknown	Unknown	Unknown	14
2016	Unknown	Unknown	Unknown	Unknown	Unknown	15
2017	Unknown	Unknown	Unknown	Unknown	Unknown	16
2018	Unknown	Unknown	Unknown	Unknown	Unknown	17
2019	Unknown	Unknown	Unknown	Unknown	Unknown	18
Total	Unknown	Unknown	Unknown	Unknown	Unknown	80

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2019) US$

Period	Research & Development Incl. Surface Exploration & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
2010-2014	2	0	0	2	25	75
2015-2019	4.2	54.8	5.6	53.4	43	57