Geothermal Energy Development in Canada—Country Update 2012

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ABSTRACT

This report provides a review of the current status of geothermal energy development in Canada, including an overview of the country's geothermal resource potential, the geothermal projects currently being developed, a description of the current geothermal energy market and its players, as wells as the activities being led by the Canadian Geothermal Energy Association (CanGEA) that work to promote and help foster geothermal energy development in Canada.

According to a report released by the Geological Survey of Canada in 2011, Canada has "tremendous geothermal resource potential." Despite the favourable opportunities for geothermal development in Canada, the market for geothermal power and direct use of heat has remained stagnant.

As the collective voice of Canada's geothermal power and direct use of heat industry, CanGEA is working on behalf of its members to promote geothermal development by working to create a favourable legal framework and support scheme on both a federal and provincial/territorial level in Canada.

In a joint effort with government and industry, CanGEA is developing a National Geothermal Database, provincial/territorial geothermal favourability maps, commencing work on a Geothermal Power and Direct Use of Heat Technology Roadmap and Implementation Framework, and making continued efforts to bring geothermal to the oil & gas sector of Canada.

Canada's Geothermal Resource Potential

In June 2011, the Geological Survey of Canada (GSC) and a team of leading scientists in the field of geothermal energy released a report on the "Geothermal Energy Resource Potential of Canada" (Open File 6914). Key findings of the report indicate that Canada has "enormous geothermal energy resources that could supply the country with a renewable and clean source of power." It further concludes that the high capacity factor of geothermal makes it "particularly attractive as a renewable base load energy supply" for Canada.

Along with the report, the GSC released updated national geothermal resource maps. These maps illustrate high heat flow regions of western and northern Canada that if developed could provide usable energy for space heating and electricity generation.

The geothermal resource potential of Canada is directly related to the country's regional geology but for the purpose of this report will be characterized into four main geographical regions: Western Canada (British Columbia and Alberta), Central Canada (Saskatchewan and Manitoba), Eastern Canada (Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland and Labrador), and Northern Canada (Yukon, Northwest Territories and Nunavut).

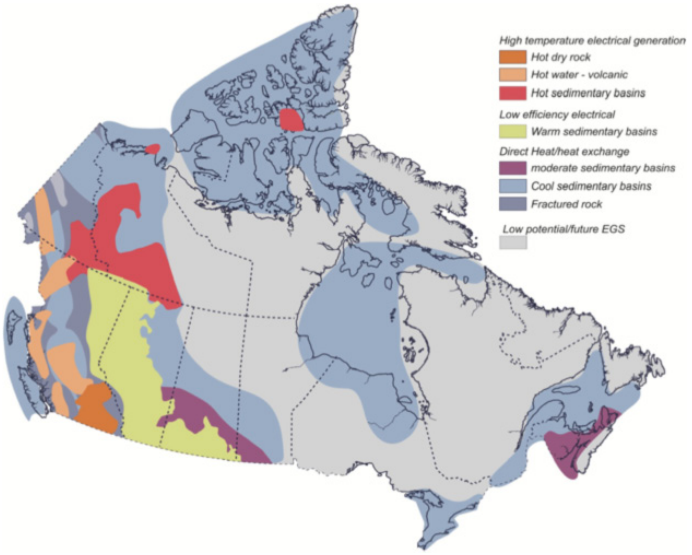

Figure 1. Canadian Geothermal Resource Potential.[1]

Western Canada

The Canadian Cordillera, which stretches northward from British Columbia to the Yukon, offers the greatest potential for high temperature geothermal resources (>150°C) in Canada. The tertiary intrusive rocks of the Western Canadian volcanic belt have significant heat generation and high geothermal gradients as a result of radiogenic elements within the rocks. These tectonic boundaries also show some of the highest heat flow values in Canada, particularly in the Garibaldi Belt. In such areas, the presence of thermal springs, geysers and vents are common. Currently, 140 thermal springs have been identified in the Cordillera with waters exceeding 10°C, however, others springs may have yet to be discovered. These local geothermal anomalies identify sites where there is an active deep groundwater circulation system, which may be utilized for direct heating and electricity production.

Previous research and drilled boreholes at Mount Meager showed measured temperatures of 200°C at a depth of 365m, also demonstrating the presence of a strong hydrothermal system. Hydrothermal systems are the most efficient and desirable resource for electricity generation but are limited in Canada to areas of the Cordillera with recent volcanic activity. Apart from the possible presence of localized hydrothermal systems, Western Canada may also be considered as a potential site for Enhanced Geothermal Systems development. Tertiary intrusive rocks surrounding Mount Meager, Mount Cayley, Mount Edziza and much of the Canadian Cordillera are hard rocks with low porosity. Fracturing the rocks would provide permeability and the artificial transfer of water to and from these high temperature resources.

Central Canada

The geothermal resource potential of Central Canada is dependent on the sedimentary basin aquifers present. Alberta and parts of Saskatchewan are located within the Western Canada Sedimentary Basin (WCSB), where moderate temperatures are present. Depending on the thickness of the sedimentary rock, the geothermal gradient can be anywhere from 25°C - 40°C/km. Temperature at the base of the sedimentary basin increases from east to west, with the highest heat flow values located in northwestern Alberta. Areas with temperatures exceeding 80°C may be considered for electricity generation with the use of binary cycle plant technology. While binary technology could be used for electricity generation, there are also great opportunities in utilizing geothermal energy in direct use applications.

A well drilled on the University of Regina campus during the Geothermal Energy Program of the 1980s showed a strong aquifer formation and stable supply of water at 60°C. The Williston basin in Southern Saskatchewan showed similar temperatures ranging from 60°- 70°C within a 2,000m depth. The Deadwood Formation near Estevan also yielded temperatures as high as 130°C, however, these geothermal resources have varying levels of salinity that may require additional engineering design to avoid precipitation of solids upon cooling.

Given the number of petroleum and gas wells located in the WCSB of Alberta and Saskatchewan, the potential for co-produced fluids is also great. By installing a binary cycle into the well system, hot water/brine extracted from the well may instead be used to generate electricity before being re-injected back into the well. Furthermore, the region has potential for the development of Enhanced Geothermal Systems (EGS) to support heat loads in the oil sands region.

Eastern Canada

Apart from the very southern portion of Ontario that lies within the Michigan basin, the greater portion of Ontario and Quebec is part of the Canadian Shield. The Canadian Shield is comprised of old, igneous/metamorphic rocks that have low heat generation and high thermal conductivity and low geothermal gradient. As most of the rocks within the Canadian Shield are also granitic/gneissic rocks, there is no inherent permeability and no expectation of underground reservoirs of thermal waters. While the high thermal conductivity within the Canadian Shield may not be attractive for electricity generation, the high thermal conductivity of the Shield is considered ideal for direct use of warm water.

Eastern Canada has many flooded underground and open pit mines which can be exploited as a geothermal resource using groundwater and surface water heat pumps. Serving as a water reservoir, mines in Sudbury and Timmins, Ontario, as well as mines in Rouyn-Noranda and Val d'Or, Quebec, have been identified as potential target areas for district scale heating and cooling. Since being a major research focus of the Geothermal Energy Program in the 1980s, an old mine site in Springhill, Nova Scotia has been used for heating and cooling buildings.

Both the Anticosti basin, which extends from the Gulf of St. Lawrence to the southeastern coast of Labrador, and the Cumberland basin of Nova Scotia and New Brunswick are deep sedimentary basins yielding low to moderate temperature resources. These geothermal resources are ideal for direct heating and cooling but also have potential for co-produced fluid or binary electricity generation.

Northern Canada

Northern Canada has significant potential for geothermal electricity generation and some of the country's highest temperature resources. Hot sedimentary basins are located in western portions of the Northwest Territories, eastern Yukon and in localized areas of the Mackenzie corridor, the Sverdrup Basin and the Foreland basins. Heat flow in this region is estimated at anywhere from 50-100 mK/m with temperatures believed to exceed 150°C at a depth of 3500m. However, given the low populations present, only certain areas may be beneficial for electricity generation. These areas include isolated communities near high heat flow values, such as Resolute Bay. Other areas within the Mackenzie Corridor, where oil and gas development is high, may benefit from co-produced geothermal or direct heating and cooling of smaller town centres. There is ongoing work by the government of the Northwest Territories and Yukon Energy into exploring the geothermal potential of the region.

Geothermal Development in Canada

There are currently eight geothermal projects in Canada including five geothermal power projects, one combined heat and power project and one direct use project.

Power generation projects

Project	Developer	Province/ Territory	Status
Swan Hills	Borealis GeoPower	Alberta	Co-produced fluids project of 2MW
Canoe Reach	Borealis GeoPower	British Columbia	Feasibility phase
Lillooet	Alterra Power/ 2149749 Ontario Inc.	British Columbia	3 permits
South Meager	Ram Power	British Columbia	Under development
Ft. Liard	Borealis GeoPower	Northwest Territories	Feasibility for 1MW pilot project
Rafferty	Deep Earth Energy Production Corp.	Saskatchewan	Feasibility

Direct use projects

Project	Developer	Province/ Territory	Status
Ft. Liard	Acho Dene Koe First Nation, Borealis GeoPower	Northwest Territories	Feasibility stage
Con Mine	City of Yellowknife	Yellowknife, NWT	unknown

Figure 2. Overview of current projects in Canada.[2]

The province of British Columbia is currently the only province of Canada with existing geothermal legislation. The Geothermal Resources Act not only defines a geothermal resource but provides a legislative agreement for ownership of geothermal resources, acquisition of permits and leases, general prohibitions, and conservation of geothermal resources.

While British Columbia has the highest geothermal resource potential estimated, the Northwest Territories and Saskatchewan have great potential to be the first territory or province to develop a geothermal power plant in Canada.

Geothermal Energy Industry in Canada

In preparation for the Geothermal Power and Direct Use of Heat Technology Roadmap, CanGEA has developed a Supply Chain Overview and Sector Profile for the Canadian geothermal energy industry. These documents provide an evaluation of the Canadian geothermal energy sector's current state of development and interaction with other sectors and international markets, and the necessary steps for growth and international competition. The report also provides an evaluation of the geothermal energy sector's strengths, weaknesses, risks, and opportunities.

The report defines the supply chain segments, identifying companies currently active in the Canadian geothermal market, but also companies that could either directly or indirectly become part of a growing geothermal energy industry in Canada.

The geothermal power and direct use of heat supply chain in Canada may be considered more advanced compared to the current state of development of geothermal projects in the country.

The international activities of Canadian developers, the experienced oil & gas and mining industry sectors, combined with a strong service sector, provide a solid basis for geothermal development.

As described by individual industry segments, there are either Canadian players that have geothermal experience internationally, or international players with a subsidiary in Canada that could serve an emerging geothermal market.

The main weaknesses of the sector are a lack of geothermal programs focused on the utilization of geothermal energy for generation of power and heat including adequate resource maps, a lack of concrete incentives for development in Canada, and an insufficient legislative environment.

The supply chain overview confirms the need to deploy pilot projects to not only prove the possibilities of the market but also to attract larger industry players to join the geothermal energy industry in Canada.

Canada could be a leader in geothermal energy utilization in a relatively short period of time. Many of the countries currently leading geothermal energy production required significant time and effort to achieve their current status. Canada has the potential to move forward and adapt much more quickly to geothermal development, given the country's strong natural resources heritage and industry infrastructure.

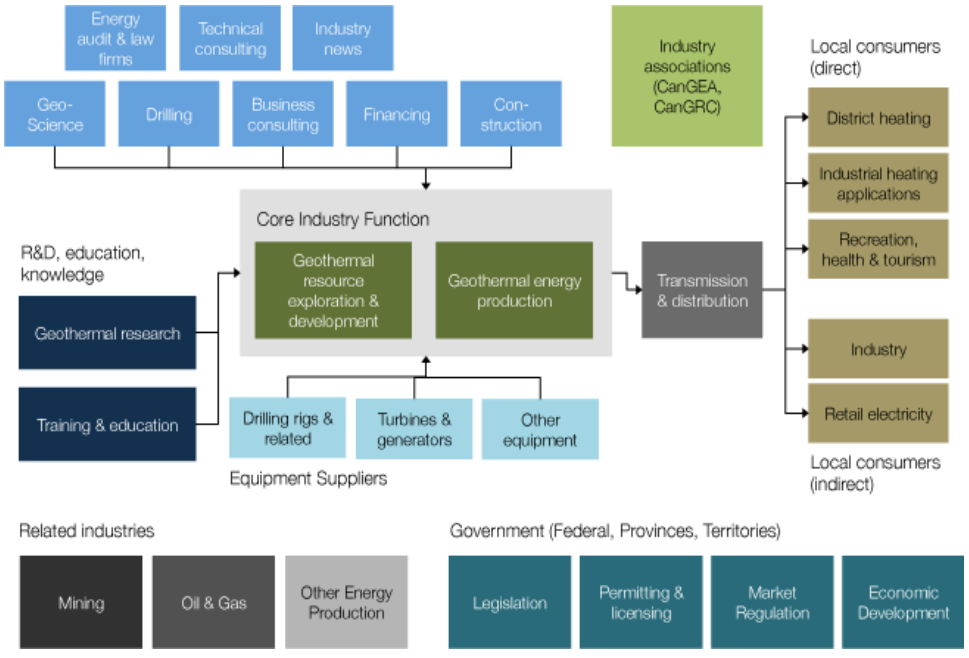

Figure 3. The Canadian geothermal energy market[3]

National Geothermal Database and Favourability Maps of Canada

CanGEA, in a joint effort with government and industry sponsors, is in the process of compiling data sets for a national geothermal database and geothermal favourability maps, starting with the province of Alberta. The geothermal favourability maps will be developed based on the EGS Protocol[4] and the Canadian Geothermal Code for Public Reporting released by CanGEA in 2009. Similar to projects already completed in Australia and the United States, these maps will provide a layered approach to mapping and will deliver publically available databases, protocols and tools used to assess geothermal resources in a globally self-consistent manner. The database and subsequent maps will allow investors to choose the most favourable areas for geothermal development based on the triple bottom line criteria of economics, environmental and social aspects.

Co-production of geothermal energy with current oil and gas development also offers a large incentive (added revenue from geothermal power, heat and CO_2 credits) in Canada while prolonging the life of the well. CanGEA, with support from its members, will investigate the current technology state of geothermal co-production using datasets for thousands of wells in Western Canada (BC, AB, SK, NT, and YT). Geothermal Favourability Maps following the Global Protocol and the Canadian Geothermal Code for Public Reporting will provide an assessment of oil sands direct heat applications via enhanced geothermal systems and the potential for co-produced fluids for each individual province and territory.

Conclusion

Canada continues to occupy an interesting position as a nation with vast geothermal potential, extensive knowledge and expertise in geothermal development, but has so far not been able to start geothermal power generation. There is though hope on the horizon with two to three small projects in line to become the first geothermal power plants in the country within the next two years. The industry continues to struggle receiving attention and support by governments and government bodies on provincial and federal level. As the collective voice of the Canadian geothermal energy sector, the Canadian Geothermal Energy Industry continues to promote and push for geothermal development and government support. With its recent work on a Supply Chain Overview, Sector Profile and favourability maps for the country, CanGEA has been able to take important steps towards creating a better basis for awareness and development. At the same time the Geothermal Power and Direct Use of Heat Technology Roadmap and Implementation Framework for Canada is being initiated. CanGEA trusts that these efforts will help kick-starting an industry that has not yet been able to live up to its potential.

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[1] Source: Geological Survey of Canada, Open File 6914

[2] Current power generation and direct use projects in Canada and their location (source: CanGEA 2012 Canada Geothermal Project Overview)

[3] Based upon similar overviews created by Íslandsbanki and Iceland Geothermal.

[4] The EGS Protocol is a "living document" that provides a mechanism to estimate and map the theoretical and technical potential for enhanced geothermal systems in a globally self-consistent manner. In early September 2011, the IEA-GIA Executive Committee endorsed the May 2011 version, published as: A Protocol for Estimating and Mapping Global EGS Potential by G. Beardsmore, L. Rybach, D. Blackwell and C. Baron.