Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

Geothermal Development in Canada: Country Update

Alison Thompson

Canadian Geothermal Energy Association. PO Box 1462 Station M, Calgary, Alberta, Canada T2P 2L6

alison@cangea.ca

Keywords: Canada, Development, Policy, CanGEA, Research, Meager, Mines,

ABSTRACT

In recent years Canada has steadily embraced heat-pump geothermal technology. Approximately 35,000 Canadian homes and buildings currently receive heating and cooling through geo-exchange installations. However, policy obstacles still exist which prevent extensive development of Western Canada's high-temperature geothermal resources for electrical generation.

The cumulative Canadian geothermal resource remains poorly quantified due to a 25 year hiatus in Federal government funding of geothermal science. Through commercial avenues, approximately 100MW of geothermal power potential has been identified as of 2009, although there is still no geothermal power in Canada's electrical grid. As an under-explored geothermal resource, Canadian geothermal projects will represent a pertinent frontier for commercial development in the near future. The corporate and public awareness of geothermal technologies has grown in the recent past through an increased media focus, and a strengthening support for carbon-friendly lifestyle choices.

Currently, the Canadian Geothermal Energy Association is leading 33 government policy projects at the Federal and Provincial levels to establish a foundation for the imminent development of geothermal electrical projects. In the Western Canadian geothermal corridor, most of the local power is generated hydroelectrically, although neighbouring export markets still generate a significant amount of power from fossil fuels. As the effect of recent carbon taxes permeate electricity markets in 2009, new geothermal projects will be well positioned to fill the vacuum with clean and reliable power

1. INTRODUCTION

Canada has maintained a position of significance as a fallow frontier for the development of geothermal energy, particularly in the field of high-temperature hydrothermal resources. Although the high-temperature resource is geographically restricted to the Province of British Columbia (BC) and the Territories of Yukon and Northwest Territories, as much as 5,000 MW_e of economically-feasible geothermal potential is believed to exist in this region (Ghomshei, 2009). What continues to preclude the emergence of a geothermal power industry in Canada is the dearth of supportive government policy. To place this in context, only one geothermal power project has ever made it to the testing phase.

Conversely, Canadians have embraced geothermal energy for heating and cooling purposes nation-wide. Particularly, the installation of ground-source heat pumps (GHP) has flourished in recent years under a scheme of direct consumer subsidy in several Provincial jurisdictions. Direct-use applications of geothermal energy have not grown materially in Canada in many years.

Through the episode of inflated world energy prices between 2005 and 2008, Canada's Federal government introduced several initiatives aimed at bolstering Canada's renewable energy portfolio. Notably, in 2008 a goal was presented to derive 90% of Canada's electricity from "non-emitting" sources by 2020; in 2009 non-emitting sources accounted for 70% of Canada's total generation. In spite of the perceived impetus to diversify Canada's renewable energy supply, geothermal power has not obtained favour in the Canadian political arena.

Canada is a unique case where separate industry associations are responsible for high-temperature geothermal resources and low-temperature resources (related to GHP) respectively. The Canadian Geothermal Energy Association oversees the interests of the high-temperature geothermal community, whereas the Canadian Geo-Exchange Coalition (CGC) maintains jurisdiction over the GHP industry.

Re-established in 2007, the Canadian Geothermal Energy Association (CanGEA) has led the effort to establish constructive policy for Canada's geothermal power industry. CanGEA works with government at the Provincial and Federal levels to demonstrate the extensive benefits of geothermal power and to suggest policy which will cultivate a profitable and sustainable geothermal power industry in Canada.

2. GEOLOGY BACKGROUND

Geothermal energy is an accessible resource all 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, two distinct volcanic regions with Quaternary eruptive episodes constitute the areas of greatest interest to geothermal power production.

2.1.1 Garabaldi Volcanic Belt

The Garabaldi 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 which 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 power (Jessop, Ghomshei, & Drury, 1991).

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 is 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, Ghomshei, & Drury, 1991).

2.2 Sedimentary Geology

The Western Canada Sedimentary Basin (WCSB) is a vast sedimentary basin, which consists of a maximum of 6km of stratigraphy in its western margin, thinning to 0m at the eastern basin edge (Wright, McMechan, & Potter, 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, although the great majority of water found in the porous formations of the WCSB are not of sufficient temperature to be considered useful for geothermal application. 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, Ghomshei, & Drury, 1991).

3.0 CURRENT GEOTHERMAL RESOURCES AND POTENTIAL

Prior to the 1970`s the use of geothermal energy in Canada was restricted to direct-use in the hot springs and spas of several western Canadian resorts. Although the number of commercialized hot springs grew with the degree of western Canadian settlement, the understanding of Canada`s geothermal resource was not of high importance. Following the oil crisis of the mid 1970`s, Canada`s Federal government was prompted to explore geothermal energy, among other forms, as an alternative to fossil fuel consumption. Beginning in 1973, the Federal and Provincial government of BC led an effort to determine the potential of the high-temperature hydrothermal resources in the south-west part of the province, where a power market and transmission infrastructure would permit commercial development. The discovery of geothermal potential at Mount Meager and Mount Cayley gave rise to a focused delineation program at Mount Meager, which eventually would incorporate deep exploratory drilling. Unfortunately, the combined effect of falling oil prices in the mid 1980`s and financial constraints of BC Hydro (The utility corporation owned by the BC government) led to the termination of the joint government geothermal program in 1986. Since then, activity contributing to the further understanding of Canada`s geothermal potential has been sparse. In a climate of low hydrocarbon prices and waning interest in the environmental merits of renewable, commercial interests in Canada`s geothermal were dormant until recent oil price spikes in the mid 2000`s. Consequently, a great deal remains to be investigated to fully comprehend Canada`s geothermal energy potential.

3.1 High-Temperature Hydrothermal Resources

The power generation potential of Canada`s high-temperature hydrothermal resources has been estimated as high as 10,000 MW_e by the year 2020 (Ghomshei, 2009). Of this however, only 100 MW_e has been reliably confirmed (GeothermEx Inc., 2004). Further, the only project which has reliably demonstrated any geothermal potential in Canada is the South Meager Creek development, owned by Western GeoPower Inc.

3.1.1 South Meager Creek

South Meager creek has ostensibly been the nucleus of high-temperature geothermal activity in Canada since the mid-1980s. Since BC Hydro sold the project to a private interest in 1985, ownership of the South Meager project has changed no fewer than 3 times, now held by Canadian-Based Western GeoPower Corporation. In 2004-2005, the project reached the most advanced stage of its drilling program, completing three production-size test wells, bringing the total number of wells drilled in the project site to 8. This asserted prior estimates that hydrothermal reservoirs of the South Meager site (220°C to 275°C) could support up to 100 MW_e of generation facilities. However, finding suitable permeability to begin commercial production delayed the project measurably, and additional testing was required in 2008 to advance the project to an appropriate level for permitting. Further, issues outside the technical realm, such as BC's unique First Nations land claims, may impart additional difficulty in bringing Canada's first megawatt of geothermal power to fruition.

3.2 Direct-Use Geothermal

Many resort communities in western Canada have derived extensive benefit from hot springs as a draw for tourism. Ghomshei et al. (2005) identifies 150 hot springs in Canada. Based on estimates of using between 100 and 400 GPM of hot-spring water each, the most developed of the western Canadian hot-springs employ between 10 to 15 MWt of geothermal energy each year between their pool heating and space heating functions. The vast majority of identified hot spring sites, however are not developed and remain in their pristine, natural condition.

Potential may exist however for a larger range of industrial applications for direct-use geothermal heat. Between direct-use and heat pump applications, Majorowicz et al (2009) suggest that up to 1.1×10^{21} J is available in Canada for heating applications. Particularly in the Western Canada Sedimentary Basin, where petroleum industry infrastructure permits access to geothermal resources at great depth, potential applications for agriculture (i.e. greenhouses), aquaculture, heating and refrigeration have been postulated. A notable attempt at developing direct-use heating in the WCSB occurred in 1981, when the Canadian Federal government sponsored a project to drill a geothermal well on the campus of the University of Regina. Brine temperatures of 62°C were found at a depth of 2200m, although a second well for injection of depleted brine was never completed, and the project was abandoned.

3.3 Ground Source Heat Pumps

Canada has experienced sustained a growing interest in ground source heat pump (GHP) technology. Due in part to the large quantity of fossil fuels consumed during cold Canadian winters, Canada has one of the highest CO_2 emissions per Canada in the world (Energy Information Administration - US Government, 2006). For this reason, there is a large potential to curtail Canada's carbon footprint through the use of GHP technology. According to one government estimate, up to 50,000 residential GHP systems, and a further 5,000 commercial GHP systems are likely in use today (Natural Resources Canada, 2008). Current GHP installations are preventing an estimated 200,000 metric tonnes of CO_2 emissions per year in Canada (Canadian GeoExchange Coalition, 2009).

Although the nature of the shallow subsurface is highly variable across Canada, a geothermal potential map by Grasby (2006) identifies that the majority of Canada's population centres are suitably situated to harness heat pump technology. The unfavorable areas for heat pump technology strongly correlate with exposure of the

Canadian Shield, which is a vast area of crystalline rock, bereft of thick soil or sedimentary cover.

The costs for building retrofit with GHP systems are still prohibitive for the average consumer. However, through the assistance of Federal and Provincial subsidy programs such as ecoENERGY, which offers businesses up to C$50,000 for a GHP retrofit (Natural Resources Canada, 2009) the number of GHP installations per year in Canada has grown steadily at an average rate of 13% (Natural Resources Canada, 2008).

3.3.2 Heat Pump Technology in Abandoned Mines

Several Canadian mines have been the focus of new studies to determine the feasibility for using warm, geothermal waters in geo-exchange applications. The benefit of depth, and water-storage potential of mining excavations creates a favorable setting for a low-temperature geo-exchange thermal reservoir. This holds promise that some of Canada's many relict mining projects can be converted from a condition of liability into an economically feasible heat resource.

As early as 1989, businesses in Springhill, Nova Scotia were using the waters from flooded coal mine workings for space and water heating. The flooded water, which maintains a relatively constant temperature of 18°C, is harnessed in a 10-unit heat pump system, where it can be configured produce the desired heating or cooling effect. The water is then discharged into a separate drift of the mine, where it will eventually communicate with the original thermal reservoir. This saves the industrial complex net C$45,000 in energy costs, the equivalent of 600,000 kWh of electrical consumption (International Energy Agency, 1992).

In 2007, the city of Yellowknife in the Northwest Territories commissioned a concept study to determine the viability of using geothermal waters from an abandoned gold mine to provide district heating (Ghomshei, 2007). Yellowknife is one of the northernmost population centres in Canada. Due to its remote location, the city relies on expensive diesel fuel for most of its heating. The geothermal waters at the deepest point in the Con Mine, located as close as 1.5 km to the Yellowknife city centre maintain a temperature of 35°C, in sharp contrast to the ambient air temperature in the city of Yellowknife, which can experience seasonal lows of -30°C in winter. Ghomshei (2007) proposes that an open-loop geothermal system could supply as much as 20% of the city's heating requirement, which would translate into savings of C$13 million per year

4.0 CONCLUSION

Geothermal energy in Canada continues to make forward progress through the avenue of ground source heat pump (GHP) systems. However, realizing Canada's full potential for direct-use geothermal and geothermal power generation is largely contingent on the governments' willingness to enact policy that is hospitable towards the exploration and research arms of Canada's geothermal community.

The technical challenges that hinder the feasibility of geothermal projects in Canada have receded as geothermal technology advances in other parts of the world. When the political impetus for geothermal energy strengthens in the near future, the international community can expect abundant opportunity for development and advancement through the Canadian geothermal frontier.

WORKS CITED

Canadian GeoExchange Coalition. (2009). *GeoExchange General Questions*. Retrieved from http://www.geo-exchange.ca/en/geoexchange_general_questions_faq2.php

Edwards, B., & Russell, J. (2000). Distribution, nature, and origin of Neogene–Quaternary magmatism in the northern Cordilleran volcanic province, Canada. *GSA Bulletin* , 1280-1295.

Energy Information Administration - US Government. (2006). *Internation Carbon Dioxide Emissions and Carbon Intensity 1980-2006*. Retrieved from http://www.eia.doe.gov/emeu/international/carbondioxide.html

Geological Survey of Canada. (2008). *Stikine volcanic belt*. Retrieved from Catalogue of Canadian Volcanoes: http://gsc.nrcan.gc.ca/volcanoes/cat/belt_stikine_e.php

GeothermEx Inc. (2004). *Report on the South Meager Geothermal Resource, BC, Canada.*

Ghomshei, M. (2007). *Geothermal energy from Con Mine for heating the city of Yellowknife, NWT: A concept study.* Yellowknife: City of Yellowknife.

Ghomshei, M. (2009). New Frontiers in Geothermal Energy. *A Presentation at the Canadian Geothermal Energy Association Annual Conference* . Vancouver.

Ghomshei, M., MacLeod, K., Sadlier-Brown, T., Meech, J., & Dakin, R. (2005). *Canadian Geothermal Energy Poised for Takeoff.* Antalya: Proceedings of the World Geothermal Congress 2005.

Grasby, S. (2006). Geothermal Potential of Canada (Map). Natural Resources Canada.

International Energy Agency. (1992, October). Geothermal mine water as an energy source for heat pumps. *CADDET Case Studies* .

Jessop, A., Ghomshei, M., & Drury, M. (1991). Geothermal Energy In Canada. *Geothermics* , 369-385.

Majorowicz, J., Grasby, S., & Skinner, W. (2009). Estimation of Shallow Geothermal Energy Resource in Canada: Heat Gain and Heat Sink. *Natural Resources Research* , 95-108.

Natural Resources Canada. (2008). *Clean Energy Portal - Building Systems*. Retrieved from http://www.cleanenergy.gc.ca/tech_dict/index_e.asp?ac=96&sc=182&sc_i=1&ac_i=1

Natural Resources Canada. (2009). *ecoENERGY Retrofit Incentive for Buildings*. Retrieved from Office of Energy Efficiency: http://oee.nrcan.gc.ca/commercial/financial-assistance/existing/retrofits/index.cfm?attr=0

Wright, G., McMechan, M., & Potter, D. (1994). Chapter 3: Structure and Architecture of the Western Canada Sedimentary Basin. In G. Mossop, *Atlas of The Western Canada Sedimentary Basin.*