AN OVERVIEW OF GEOTHERMAL ENERGY IN BRITISH COLUMBIA

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ABSTRACT

In British Columbia there is significant interest in finding ways to meet increasing demand for energy without producing additional greenhouse gases. The provincial government is also committed to becoming self sufficient in electricity generation. There is potential in British Columbia for geothermal resources to provide a clean source of energy and help the province meet these objectives.

The last major geothermal energy program by the Canadian government ended in 1986. Due to a revival of interest in geothermal, the British Columbia Ministry of Energy, Mines and Petroleum Resources and the Geological Survey of Canada are working to establish the geothermal geoscience needs of western Canada and to determine the role of government geoscience agencies in addressing these needs.

Lee, C., (2009): An Overview of Geothermal Energy in British Columbia ; Geoscience Reports 2009, *BC Ministry of Energy, Mines and Petroleum Resources*, pages 49–52.

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Key Words: geothermal, clean energy, electricity, direct use, baseload, co-production, high temperature, resource assessment

INTRODUCTION

A focus of the BC Energy Plan (BC MEMPR 2007) is to ensure energy self-sufficiency in British Columbia. Due to global climate change concerns, this must be done in a way that minimizes the release of greenhouse gases (GHGs). Geothermal energy is one option to help British Columbia meet its energy needs; it is a low GHG form of energy and previous government research has identified areas of geothermal potential in the province.

GEOTHERMAL BASICS

Geothermal energy is the heat contained within the Earth. This energy can be used either indirectly to produce electricity or directly to provide heat for buildings, agriculture (e.g., greenhouse heating), or industrial uses (e.g., pulp and paper processing). Geothermal energy can also be used on a smaller scale by geoExchange systems, also referred to as heat pumps, in buildings and homes. The temperature, depth, and location of the resource, as well as whether fluid and permeability are present, determine the ways in which it can be used and whether development is economically feasible. Geothermal energy generates a negligible amount of greenhouse gases and has a relatively small environmental footprint.

In order to extract the heat from underground, a carrier is needed to bring it to the surface. In most cases the carrier is steam (in vapour-dominated reservoirs) or water (in fluid-dominated reservoirs), although in theory other carriers (e.g., carbon dioxide) could be used. Some sites have a reservoir of heat without permeability or an associated carrier. These reservoirs can be fractured and have water artificially added to them to act as a carrier. Such systems are referred to as enhanced geothermal systems (EGS) or hot dry rock (HDR). Abandoned mines can also be used as geothermal reservoirs. For example, water from flooded mines has been successfully used to heat several buildings in Springhill, Nova Scotia (Jessop 2008a).

When generating electricity, different types of power plants are used depending on the type of resource. In the case of a vapour-dominated reservoir (or a very hot water reservoir where the water can flash to steam once the pressure is reduced), the steam can be used directly to run a turbine. If the resource is not hot enough to produce steam, then a binary plant can be used. These plants use the water from the geothermal resource to heat a secondary fluid with a lower boiling point than water; the vapour of the secondary fluid then runs the turbine.

When used to generate electricity, geothermal is a baseload resource; plants are online approximately 95% of the time (Duffield and Sass 2003). Many other alternative sources of electricity, such as wind or solar, are dependent on the weather and time of day and operate at or near their maximum capacity for limited amounts of time.

The location and depth of the resource are factors that influence the feasibility of development. For power generation, it is important that the resource is close to the power grid or the end user, as building power lines across long distances is costly. When the resource is to be used directly for providing heat, it must be used close to the source; piping water a long distance will allow it to cool. The cost of drilling increases with depth, so shallower resources are cheaper to exploit than deeper ones.

GEOTHERMAL IN BRITISH COLUMBIA

Geothermal electricity is used in many areas throughout the world (Table 1). Italy has operated a geothermal plant at Larderello for over 100 years, and New Zealand has been producing geothermal electricity for 50 years (Bertani 2006). Areas of active tectonism, young volcanic belts, radiogenic plutons, and the occurrence of hot and warm springs throughout the province indicate geothermal potential in British Columbia. Although geothermal electricity was produced in British Columbia during a test project at Mount Meager, British Columbia does not yet have commercial geothermal electricity production. This is partly because of the large, relatively inexpensive hydroelectric power resource that the province enjoys as a result of its rugged topography and abundant rainfall. Due to increasing demand for electricity, the need for electricity self-sufficiency, and the desire to reduce GHGs, British Columbia is interested in developing a larger variety of low GHG energy sources and geothermal may be able to help the province meet its energy needs (BC MEMPR 2007).

While there is not yet a study that provides a firm estimate of geothermal potential, an overview of the province's geothermal potential is illustrated in the map "Geothermal Resources of British Columbia" (Fairbank and Faulkner 1992). The map indicates 18 general areas of low, moderate and high temperature geothermal potential throughout the province. These areas include: the Garibaldi Volcanic Belt, Pemberton Belt, Harrison Lake area, Okanagan Val-

TABLE 1. COUNTRIES WITH GEOTHERMAL POWER GENERATION AS OF 2005. ADAPTED FROM BERTANI 2006.

Country	Installed Capacity (MW_e)	Annual Energy Produced (GWh/y)	Number of Units
Australia	0.2	0.5	1
Austria	1.2	3.2	2
China	28	96	13
Costa Rica	163	1145	5
El Salvador	151	967	5
Ethiopia	7.3	0	2
France (Guadeloupe)	15	102	2
Germany	0.2	1.5	1
Guatemala	33	212	8
Iceland	202	14838	19
Indonesia	797	6085	15
Italy	791	5340	32
Japan	535	3467	19
Kenya	129	1088	9
Mexico	953	6282	36
New Zealand	435	2774	33
Nicaragua	77	271	3
Papua New Guinea (Lihir Island)	6	17	1
Philippines	1930	9253	57
Portugal (Sao Miguel Island)	16	90	5
Russia	79	85	11
Thailand	0.3	1.8	1
Turkey	20	105	1
United States	2564	17917	209
Total	**8933 MW_e**	**56786 GWh/y**	**490 Units**

ley, Low Arrow Lake area, Kootenay Lake area, Southern Rocky Mountain Trench, Upper Arrow Lake area, Valemount area, Hudson's Hope area, Northeast British Columbia Thermal Anomaly, Liard River area, the Stikine Volcanic Belt, Mount Edziza area, Lakelse Lake, Gardener Canal area, King Island area and the Anahim Volcanic Belt.

The energy crisis of the 1970s prompted interest in geothermal energy. The National Geothermal Energy Program of the Department of Energy, Mines and Resources officially started in 1976. The program focused on identifying and examining Canadian resources, assessing the available technology, and responding to requests for advice. The Mount Meager Project was the National Geothermal Energy Program's largest pilot project in British Columbia and involved geophysical surveys, geological mapping, and the drilling of several drill holes. The project was able to show that there is a major geothermal anomaly in the area (Jessop 2008a). Other areas that were examined, in various levels of detail, in British Columbia were Mount Cayley, Anahim Volcanic Belt, Stikine Volcanic Belt, the town of Summerland (low temperature), Hot Springs Cove and the Western Canada Sedimentary Basin near Fort Nelson (Jessop 2008a and b).

Recent detailed summaries of what was achieved during the National Geothermal Energy Program are provided by Jessop (2008a and b). When the program ended in 1986, there was no official attempt to preserve the data. Former members of the program took it upon themselves to conserve, compile, and publicly release the data (Jessop et al. 2005).

British Columbia is the only province in Canada to have developed a Geothermal Resources Act (http://www.em.gov.bc.ca/Links/legislat.htm) that regulates leasing and drilling of geothermal resources. Nova Scotia also has legislation in place but only for low-temperature resources in abandoned mines (Jessop 2008a). The act is currently under review to ensure it can accommodate a recent increase in interest in geothermal resources in the province.

There are currently several active geothermal permits and one active geothermal lease in British Columbia. These are located in the Garibaldi Volcanic belt and the Valemount area in the Rocky Mountain Trench. Western GeoPower Corporation's South Meager project is the project which is furthest along in development. There has been a long history of interest in the geothermal potential at Mount Meager, it was one of the focuses of the National Geothermal Energy Program, and as a result there has been more research conducted in this area than for other areas in British Columbia.

Co-production with Oil and Gas Wells

British Columbia has an active oil and gas industry with a large number of producing oil and gas wells. Many oil and gas wells produce water as well as oil and gas. This water can be at very high temperatures. Currently produced water is re-injected into formations at a significant cost, and companies try to limit the amount of water produced. There is potential to use the water to generate electricity before the water is re-injected. This technology has recently been successfully tested at the Rocky Mountain Oilfield Testing Centre (RMOTC) in Wyoming, USA. The RMOTC and Ormat Technologies Inc. have been using an Organic Rankine Cycle binary power plant to produce power using produced water with an approximate temperature of 88 °C. Since the project began in September 2008, the unit has been producing between 150 and 250 gross kW of power (Nations 2008).

The British Columbia Ministry of Energy, Mines and Petroleum Resources (MEMPR) has provided support to the University of British Columbia for graduate research on this topic. Research is being conducted on the potential of electricity generation from produced water in gas fields south of Fort Nelson. "The Geothermal potential of Clarke Lake and Milo gas fields, northeastern British Columbia" (Arianpoo In Preparation) is expected to be completed for Fall 2009.

Geothermal Geoscience Workshop

Due to the renewed interest in geothermal energy in recent years, British Columbia MEMPR and Natural Resources Canada Geological Survey of Canada in cooperation with the Canadian Geothermal Energy Association (CanGEA) organized a workshop to discuss and prioritize the geothermal geoscience needs for Western Canada. It also addressed the appropriate roles of provincial and federal government agencies in addressing these needs. The workshop, entitled "Geoscience Needs for Geothermal Energy Development in Western Canada", was held in Vancouver in October 2008 and was attended by approximately 50 representatives from federal and provincial agencies, CanGEA, academia, and industry. The following is a brief summary of the findings and recommendations that resulted from the workshop. A complete summary of the workshop is available (Lebel 2009).

The workshop consisted of a series of presentations on specific topics related to geothermal geoscience; presentations were followed by break-out discussion groups on similar topics. The following three questions were presented to participants to help focus the presentations and discussions:

1. What are the key geothermal energy resources and tools?
2. What geoscience is needed to support geothermal energy development?

3. What is the appropriate role of a government geological science agency in addressing these geoscience needs?

There were four key recommendations from the participants of the workshop:

1. Develop a national geothermal resource assessment.
2. Compile regional or national geothermal related geoscience databases to support geothermal energy exploration with pre-competitive geoscience.
3. Acquire new targeted geoscience information for geothermal exploration in areas with the highest potential for development.
4. Hold other forums and undertake policy analysis to advance geothermal energy in Canada.

An important workshop discussion revolved around the appropriate role of government agencies. Participants recommended that governments be the custodians of data, have a role in interpreting data, and anticipate future geoscience needs. British Columbia MEMPR is working to satisfy this recommendation by beginning to develop a database for British Columbia geothermal information. Existing geothermal data, such as files that were submitted to British Columbia MEMPR during the federal geothermal program, are being acquired and digitized, and data from other industries, such as temperatures from oil and gas wells, that are useful for geothermal exploration are being identified and collected. The goal is to build and maintain a public web-based database of geothermal information for British Columbia.

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