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THE CURRENT STATUS OF GEOTHERMAL EXPLORATION AND DEVELOPMENT IN CANADA

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ABSTRACT

Comparatively low costs for hydroelectricity and fossil fuels have had a restraining influence on levels of exploration and development for geothermal energy resources in Canada for the past several years. Since 1995, when Pacific Geopower suspended its high-temperature drilling project at Meager Creek, B.C., the focus of development has been in the areas of low temperature geothermal energy technology (involving aquifer thermal energy storage or heat pumps) and in the exploration and assessment of hotspring resources primarily for recreational applications – although possibly for other direct uses depending on local infrastructure and access to appropriate energy markets. This paper reviews the current status of the geothermal industry (both high and low temperature) in Canada.

1. INTRODUCTION

Despite the recent global mandates aimed at reducing levels of greenhouse gas (GHG) emissions, Canadians have been very sluggish to implement new projects on a large scale that are energy-efficient and that go a long way to reducing GHG emissions. The current focus appears to be studying the impact of climate change on the natural environment, not identifying what immediate measures can be taken to reduce emissions and perhaps curtail or limit the deleterious effects of climate change.

The federal government has indicated that even the best global efforts to reduce greenhouse gas emissions will only slow, not prevent, changes in climate. Thus, it is important to carefully assess the possible consequences of climate change and prepare, where practical, to adapt. As part of Canada's response to achieving its commitments under the Kyoto Protocol on Climate Change, the Federal government has set up the Climate Change Action Fund (CCAF) for the next two fiscal years. One of the components of the CCAF deals with Science, Impacts and Adaptation.

The "Science" component of the Climate Change Action Fund will focus its efforts on monitoring the state of the climate, and developing a better understanding of how the climate system works. This research ultimately will lead to better regional estimates of how fast and how much the climate will change.

The "Adaptation" component of the Action Fund will focus on developing a suitable and accessible knowledge base that can be used for wise and prudent decision making. This knowledge will enable us to better understand the need for greenhouse gas reductions and to identify and implement the most appropriate response strategies to reduce the negative impacts of climate change and take advantage of the positive ones.

Although research and development of alternative energy technologies is not part of the CCAF, there is clearly a need to incorporate this aspect of climate change action into a national program. Research in the period 1974 to present has shown that geothermal energy is found in a wide variety of geological settings, and that it is plentiful in Canada. Low temperature applications have been successfully used in several provinces (e.g., Ontario). Resources of high temperature have been demonstrated but they have not yet been used. Currently there is very little economic incentive to develop geothermal energy as an alternative energy source. This is largely because of the low costs of hydroelectricity in Canada as well as the low costs of fossil fuels, not to mention the hidden government subsidies directed to each of these. As economic and political factors change, geothermal energy may become one of the major resources to be drawn on.

2. HIGH AND MODERATE TEMPERATURE GEOTHERMAL ENERGY

From 1976 to 1986 the Department of Energy, Mines and Resources Canada, assisted by the National Research Council of Canada, made geothermal energy research one of the components of a major program of research into "Renewable Energy" sources. Most of our knowledge of Canadian geothermal resources results from that program (Jessop, 1998). One of the most significant realizations of that time was that geothermal energy is present to some extent everywhere, and not just where hotsprings and other thermal features reveal it. High-temperature hydrothermal resources are, however, believed to be associated only with the Canadian cordillera because of its tectonic youth (Jessop et al., 1992). The presence of high-temperature reservoirs associated with the cordillera are indicated by more than 100 hotsprings in British Columbia and Yukon (Jessop et al., 1992; Ghomshei et al., 1993; Ghomshei and Sadler-Brown, 1991).

2.1 Mount Meager, British Columbia

No hot dry-steam reservoirs have yet been found in Canada, but any center of recent volcanism may have one or more associated intrusive bodies that are capable of supporting hydrothermal systems leading to dry-steam reservoirs (Jessop, 1998). However, high-temperature hydrothermal reservoirs have been discovered in southern British Columbia. Deep exploratory drilling in the South Meager Creek and Pebble Creek (also known as North Meager) areas led to the discovery of hydrothermal reservoirs with temperatures exceeding 220°C (Ghomshei et al., 1992; Jessop et al., 1991).

Mount Meager is the northernmost volcano of the Cascade mountain chain that extends south into northern California. Exploration in the Mount Creek valley culminated with the drilling of three large-diameter wells during 1980 and 1983. Bottom-hole temperatures were as high as 270°C at a depth of 3500 meters. The first deep well proved to be capable of long-term, two-phase fluid production (Ghomshei and Stauder, 1989). Information from major ion (Ghomshei et al., 1986) and stable isotope data (Ghomshei and Clark, 1993; Clark et al., 1992), from fluids from the discharging well strongly suggested the presence of abundant geothermal fluids at a depths between 2500-3000m. Geothermometry suggested that these fluids had migrated upward along the Meager Creek fault zone from the deep, high-temperature (270°C) reservoir to a shallower, cooler (200-210°C) reservoir at 1600m.

Despite some technical problems such as casing failure, the first well sustained a relatively high-enthalpy discharge to run the first, and so far, the only, Canadian geothermal test generator (Jessop, 1998). The results of this exploration and drilling program were very encouraging to proponents of geothermal energy, however, the project was substantially halted in 1984 because of financial cutbacks, over-capacity in BC Hydro's infrastructure and declining energy prices.

The Mount Meager site was shown to have sufficiently high temperatures, although the presence of dry steam was not demonstrated. Nevertheless, a hot water reservoir has been demonstrated at Mount Meager, but the production capabilities of the reservoir have not been adequately determined (Ghomshei and Stauder, 1989). The Meager Creek geothermal energy project is now jointly owned by Crew Development Corporation and Guy F. Atkinson Holdings Ltd. A fourth exploration well was drilled and tested in 1995, but since that time the project has been on hold pending a more favourable market for independent power producers in British Columbia.

2.2 Western Canada Sedimentary Basin

Jessop (1998) identified a very large warm-water reservoir in the Western Canada Sedimentary Basin (WCSB). The basin, situated in Alberta and Saskatchewan, has a sedimentary cover that occupies an area of 1.26×10^6 km^2 and an average depth of 1778m. This reservoir contains the largest reasonably accessible geothermal resource in Canada. Based on estimates of porosity (11.8%) and basin temperatures (geothermal gradient of 33 $mK.m^{-1}$), Jessop (1998) estimated that the resource is larger than Canada's estimated hydrocarbon reserves by three orders of magnitude, but that economic conditions do not yet favour its development.

In 1979, a feasibility study funded by the Geothermal Energy Program led to drilling a deep test hole (2214 m). Tests showed that the geothermal potential of the lowest sedimentary strata is excellent. The temperature of the producing formations is 60°C, which is sufficient to provide a good heat supply (Vigrass and Jessop, 1984). It was intended that the producing well, with a companion reinjection well, should provide enough heat for a large sports building at the University of Regina in Saskatchewan. Unfortunately, the project was not taken to completion because the sports facility was not built.

3. LOW TEMPERATURE GEOTHERMAL ENERGY

In recent years, the use of low temperature geothermal energy, involving heat pump technology or the direct use of low-grade geothermal energy for heating and/or cooling, has increased steadily throughout Canada. Canada's cold winters coupled with growing concerns over greenhouse gas emissions suggest that this technology will be an important component of Canada's geothermal industry in the future (Ghomshei and Sadler-Brown, 1996).

The development is usually in small units, providing heat and/or cooling to commercial buildings and larger private homes. However, there are several showcase projects situated throughout the country that have proven to be economically attractive. Some of these applications have combined heat exchanger and aquifer thermal energy storage (ATES) technologies, whereby the geothermal energy is recycled in the ground to provide both seasonal heating and cooling.

3.2 Aquifer Thermal Energy Storage

ATES technology involves the seasonal or short-term storage of low-grade geothermal energy for heating and cooling. During the summer months, cold water is pumped from an aquifer and is used to cool building air. The warm water produced through heat exchange is reinjected into a second well, and is stored in the aquifer. During the winter, this stored warm water is pumped and used to heat building air. The cold water that is produced is reinjected into the aquifer and stored for the next cooling season, thus completing the storage cycle. Many large systems consist of multiple pumping and reinjection wells. ATES systems are in wide use in many other countries including the Netherlands, Sweden, Denmark, the United States and elsewhere.

ATES has been or is currently being implemented in a number of large-scale building projects in Canada. Existing large installations include, for example, the Carleton University campus in Ottawa, the Sussex Hospital in New Brunswick, and the Scarborough Centre near Toronto. Many of these have been operating since the late 1980s.

The Carleton University project draws its water from fractured limestone aquifers at a temperature of about 9°C. The project was originally designed for implementation in four phases. Phase 1 (consisting of 5 wells) opened in February 1990, and was constructed using standard heat-pump technology in combination with aquifer thermal energy storage. The system was designed to provide heating and cooling for approximately 40% of the campus buildings. The high cost of energy associated with using the heat pumps prompted the university to re-assess the original design. In 1992-1993 a retrofit was undertaken in one building such that it could be directly cooled during the summer months and pre-heated in the winter by a heat exchanger, without the use of heat pumps.

This new design (without heat pumps) formed the basis for an expansion to the system. Additional wells for Phase 2 were drilled during 1994 and were to have been incorporated with the existing 5 well system (Allen, 1996). Unfortunately, the system has never been implemented or tested because of nontechnical administrative problems. Nevertheless, two wells continue to provide heating and cooling to one building.

New ATES installations are being designed for buildings operated by Environment Canada in Ottawa and by Agriculture Canada in Agassiz, British Columbia. The Environment Canada system consists of a multiple well field, and groundwater is extracted from a fractured sandstone aquifer at an ambient temperature of about 9°C. To date, the wells have been drilled and hydraulic testing and modelling has been undertaken. Work on the building retrofit is expected to take place this year. At Agriculture Canada's laboratory facility, five wells have been drilled. Four of the wells will be used for ATES, and the fifth well will act as a dump well to dispose of a small amount of excess cold water generated in the building during the winter heating.

Research on ATES in Canada is limited; however, Canadian Scientists have been active participants in several Annexes on Energy Conservation through Energy Storage under the auspices of the International Energy Agency. The most recent Annex (13) is aimed at identifying state of the art techniques for the design construction and maintenance of underground thermal energy storage wells and boreholes.

3.2 Energy from Mine Waters

A low-temperature geothermal resource associated with abandoned coal mines at Springhill, Nova Scotia continues to provide direct use geothermal energy for space heating in an industrial development in that community. A similar project has been proposed for Nanaimo, B.C. where there is an abundance of warm water in extensive underground mine workings beneath the city.

The mines at Springhill, which ceased operations in 1958, are flooded and contain about 4,000,000 m^3 of water. Since 1989, this water has been recovered at the surface at a temperature of about 18°C. The heat in the water is derived from the normal heat of the host rocks, and the temperature is controlled by natural convective mixing of the water. Water is pumped from the mines to act as the primary input to heat pumps for both heating and cooling of commercial buildings (Jessop et al., 1995).

The water in the mine workings acts as a large reservoir of heat that is drawn on and replenished seasonally, rather than being depleted. In addition to a short payback period (approximately one year, Jessop (1998)), there are non-monetary benefits: the extraction of energy from the mine produces no combustion gas and leaves no chemical residue on the surface. Jessop et al. (1995) estimated that in the winter heating season carbon dioxide emissions from a conventional oil-based heating system that supplies 890 GJ would release about 500 tonnes of carbon dioxide. In the summer, an air-conditioning system driven by electricity produced from coal, as is most electricity in Nova Scotia, implies the release of 240 tonnes of carbon dioxide (for a total of 740 tonnes a^{-1}). The emissions necessary to produce the same benefits of heating and cooling from the geothermal source (electrical energy needed to drive the heat pumps and water pumps) total 370 tonnes a^{-1}. This results in a net reduction in carbon dioxide emissions to the atmosphere of 50%.

3.3 Other Energy Applications

Low-temperature geothermal energy sources have also been used to provide either direct cooling or a combination of heating and cooling at many large facilities across Canada. For example, the Vancouver International airport extracts groundwater from over 50 wells to cool one of the terminal buildings. The water is not reinjected into the aquifer. Unfortunately, the wells have become clogged with precipitates due to the high iron and manganese concentrations in the groundwater. Remedial action is currently underway, and the work is expected to improve the overall performance of the system.

A similar system has been operational for over three years at the Sandspit airport on the Queen Charlotte Islands. This system provides both heating and cooling to the terminal building by continuously pumping water from one pumping well and reinjecting into an injection well. There is no reversal in the flow direction in alternate heating and cooling seasons (unidirectional system).

Despite the fact that neither system incorporates ATES, which would significantly improve their efficiency and performance, both of these systems have resulted in considerable savings for the airports.

4. RECREATIONAL USE

4.1 Hotsprings

Developers continue to be interested in geothermal resources for recreational and therapeutic use in resorts in western Canada where numerous moderate and high-temperature hotsprings are known to exist. Drilling projects testing for water for these applications have been carried out in the Kootenay area of eastern British Columbia and in the Coast Mountains of southwestern British Columbia.

A recent discovery in the Canoe Reach area is associated with the rocks of the Intermontain Belt west of the Rocky Mountain Trench. The resource area is partly flooded by a hydro reservoir but the prospects for development through directional drilling are promising. Hydro-geochemical thermometery here indicates a reservoir temperature of 180° C.

The Government of Canada, through the Canadian Parks Service, has recently reviewed its policies and taken steps to improve and update facilities at several hotsprings in the national parks of British Columbia and Alberta. These include Banff, Kootenay, Jasper and the newly established Gwaii Hanaas in the Queen Charlotte Islands. British Columbia's provincial government has likewise taken steps to improve and protect popular hotsprings in its parks and recreation areas including those at Maquinna Park and Meager Creek.

CONCLUSIONS

While energy prices remain low and conventional fossil fuel resources and conventional methods of exploitation can be used, significant industrial development of geothermal energy is unlike to occur. In the current climate of reduction of scientific research and technical development, no governmental organization is supporting geothermal energy research. Proposals to national funding agencies for research on low-temperature geothermal energy (including ATES) have also been rejected in recent years. The Canadian Geothermal Energy Association has also experience a significant decline in its membership and the remaining supporters of the organization are essentially keeping the association functional in order to retain a centre of geothermal expertise in Canada.

Given the magnitude of geothermal resources in Canada and its ability to provide energy with an environmental impact significantly less than that of energy produced by combustion of fuels, geothermal energy must become a major potential source of energy for the future (Jessop, 1998).

Most recent hike in crude oil prices coupled with Canadian obligations to reduce GHG emissions suggests that there is tangible hope for the Canadian Geothermal Industry to play an important role in the future of the Canadian energy programs.

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