Geothermal Energy as an Indigenous Alternative Energy Source in British Columbia

Titi ***Kunkel*****, University of Northern British Columbia; Mory* ***Ghomshei****, McGill University & University of British Columbia; Robert* ***Ellis****, University of Lethbridge*

** Corresponding Author*

Abstract

British Columbia is anticipating a shortfall in electricity supply because of an expected increase in demand for energy by about 45% within the next 20 years, as well as the phasing out of old utilities. The reliance on fossil fuel and the ongoing discourse on climate changes have resulted in a shift towards carbon-neutral energy alternatives. The province's current energy policy goals include achieving electricity self-sufficiency by 2016 through clean or renewable sources. British Columbia has an abundance of geothermal resources with wide-ranging temperatures available for both power development and direct use. Smaller ecological footprints and lower environmental impacts make the geothermal resource a choice for sustainable energy development as part of a diversified energy portfolio. This article reviews the benefits and impacts of geothermal resource development as a complementary indigenous, alternative energy source for the province and as a potential resource to create sustainable economic development within rural and remote communities.

KEYWORDS: alternative energy; economic development; energy; First Nations; geothermal resources; sustainable resources

Introduction

British Columbia is anticipating a shortfall in electricity supply because of an expected increase in demand for energy by about 45% within the next 20 years as well as the phasing out of old utilities (Lebel 2009; Alexander 2011). The reliance on fossil fuel and the ongoing discourse on climate changes have resulted in a shift towards carbon-neutral energy alternatives (B.C. Ministry of Energy Mines and Petroleum Resources 2007).[1] The present energy policy goals of the province include achieving electricity self-sufficiency by 2016 through clean or renewable sources (B.C. Ministry of Energy Mines and Petroleum Resources 2007; Hoberg & Sopinka 2011). The province has an abundance of geothermal resources with wide-ranging temperatures available for both power development and direct use (Fairbank & Faulkner 1992). Smaller ecological footprints and lower environmental impacts make the geothermal resource a choice for sustainable energy development as part of a diversified energy portfolio (Lebel 2009). This article reviews the benefits and impacts of geothermal resource development as a complementary indigenous, alternative energy source for the province and as a potential resource to create sustainable economic development within rural and remote communities.

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The province's self-sufficiency standard has an implied export policy (Hoberg & Sopinka 2011). Moreover, it is uncertain whether the province is a net exporter or net importer of electricity, as different sources of data support both claims (Hoberg & Sopinka 2011); however, electricity supply to the United States increased by about 50%, to over \$306 million, in November 2011 compared to the previous year (Schrier 2012). Arguably, electricity supply is a source of economic revenue, accounting for approximately 1% of the province's exports (Hoberg & Sopinka 2011; Schrier 2012). Renewable energy proposals in the province include biomass, geothermal, wind, hydro, and solar (B.C. Ministry of Energy Mines and Petroleum Resources 2007). These sources of energy are indigenous and provide alternatives to nuclear energy and fossil fuel resources. Geothermal, wind, hydro, and solar have the added advantage of reduced carbon dioxide and greenhouse gas emissions, and hence are considered "green energy" sources.

Figure 1 shows the distribution of high enthalpy and medium temperature geothermal resources available in British Columbia. The province has several locations of potential gradient heat, with temperatures up to 200°C in places and increasing in some areas by up to 80°C per 1000 m depth. Some manifestations of geothermal resources are located in rural and remote communities (Fairbank & Faulkner 1992). As most of these communities need to diversify their economic portfolio and reduce their reliance on the forest industry, benefits could accrue from direct-use applications of the resource, potentially reducing their dependence on diesel for all their energy needs (Grasby et al. 2011). Leading geothermal experts claim that this sustainable resource has a lower environmental impact for the same energy output when compared to other sources (Allen et al. 2000; Massachusetts Institute of Technology 2006; B.C. Ministry of Energy Mines and Petroleum Resources 2007).

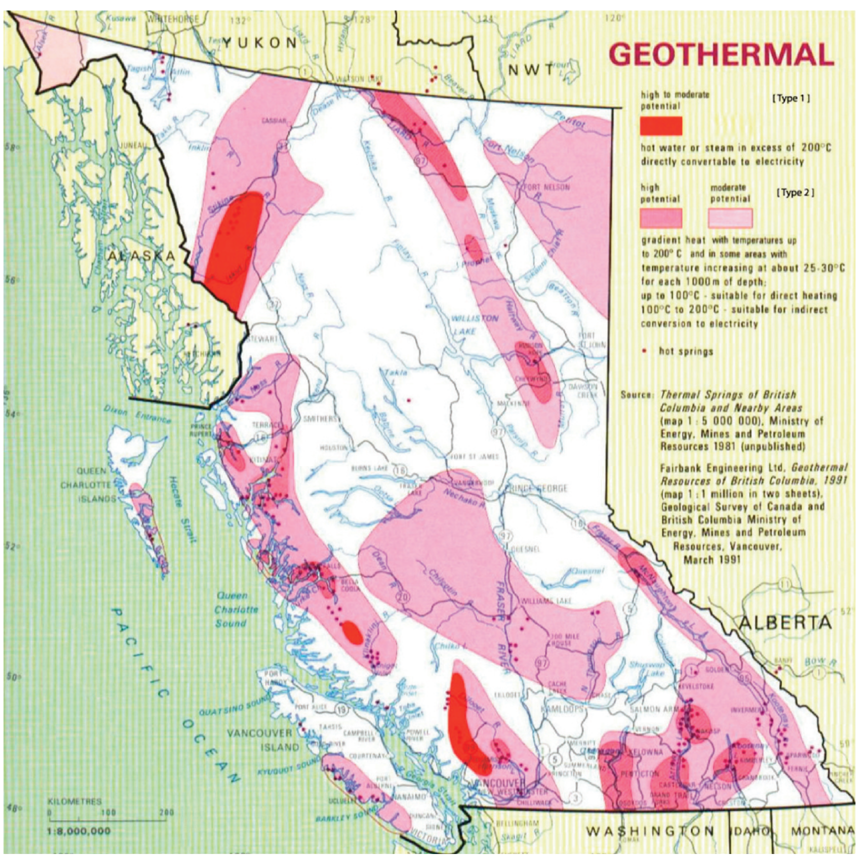

Figure 1: Map of geothermal resources in British Columbia. Source: Fairbank Engineering Ltd. 1991.

What is a geothermal energy resource?

A geothermal resource is heat energy generated and stored naturally in the Earth. This energy is directly derived from the essentially inexhaustible terrestrial heat source beneath the Earth's crust and does not rely on direct or converted solar energy (Kolar 2000). The temperature beneath the relatively thin crust of the Earth can reach up to 1300°C (Ghomshei 2008). Ghomshei (2008) estimated that 1% of the usable heat from beneath the continents, to a depth of 6 km, is equal to humanity's total energy demand for the next 10 000 years. Grasby et al. (2011) believed that as few as 100 projects could meet a significant portion of Canada's base-load energy needs.

The conditions required to develop this resource include access to heat at the right temperature (Table 1), available water such as rainfall or river water to recharge the reservoir, and permeability of the Earth's crust to allow groundwater to be freely extracted either as hot water or steam (Burgess 1989; Ghomshei 2008). For geothermal heat to be regarded as a useful energy source, a suitable combination of structural conditions must also be present at depths accessible for drilling (Burgess 1989; Grasby et al. 2011). In addition, there must be sufficient hydraulic isolation to prevent the circulating groundwater from dissipating the heat (Burgess 1989).

Table 1: Uses of geothermal energy

	Availability	Technology	Output
10°C	Everywhere	Heat pump	Heating homes, spa
50°C	Everywhere	Direct use	Heating homes and large buildings, greenhouses, spa, fish cultures
100°C[a] and < 200°C	Medium heat flow regions	Binary cycle power plant	Heat and electricity
> 200°C	High heat flow regions	Flash/dry steam power plants	Heat and electricity

Note: a) Grasby et al. (2011:27) classified 80–150°C as medium temperature resource.
Source: Burgess 1989; Ghomshei 2008

Geothermal energy is exploited at various places around the world by tapping naturally circulating hot water or by using naturally occurring steam in industrial processes (Burgess 1989; National Energy Authority and Ministries of Industry and Commerce 2004; Massachusetts Institute of Technology 2006; Lebel 2009). Most applications of the resource draw on hydrothermal reservoirs from large pools of water trapped in underground rocks and heated by the Earth's core (Kolar 2000). The power of geothermal steam is also harnessed to drive turbines for electricity production (Burgess 1989; National Energy Authority and Ministries of Industry and Commerce 2004; Massachusetts Institute of Technology 2006).

Geothermal energy is considered a renewable resource because most of the sources are steadily renewed, but this renewal takes place at varying rates depending on the reservoir; the resource could be 100% sustainable if extracted at a rate equal to or below the local geothermal heat recharge of the reservoir used (National Energy Authority and Ministries of Industry and Commerce 2004). The overall reservoir can be sustained if resource extraction is scheduled in a manner that allows different sections of the reservoir to recover heat. Grasby et al. (2011) suggested that active reservoir management and drilling additional producing wells beyond the estimate of production needs could counteract losses in productivity.

Geothermal resource development around the world

Geothermal resources are used in various applications around the world (Table 2). These uses include electricity production, spas, space heating, domestic hot water supply, greenhouse heating, swimming pools, balneology, and industrial processes (Burgess 1989; Gunerhan et al. 2001; Ghomshei 2008; Lund 2010). Direct use of geothermal resources, involving large-scale district heating projects, greenhouse complexes, and major industrial uses, is on the rise; heat exchangers are also allowing the increased use of lower-temperature resources in countries such as Canada, France, Switzerland, and Sweden (Lund 2010). Gunerhan et al. (2001) claimed that this type of heating is clean and much cheaper compared to other energy sources such as fossil fuels.

Table 2: World geothermal electricity supply in 2010

Country	Installed capacity (MW)	Ranking	Initial development date
United States	3086	1	1960
Philippines	1904	2	1979
Indonesia	1197	3	1983
México	958	4	1973
Italy	843	5	1904/1916/1946
New Zealand	628	6	1958
Iceland	575	7	1978
Japan	536	8	1966
El Salvador	204	9	1975
Kenya	167	10	1981
Costa Rica	166	11	1994
Nicaragua	88	12	1983
Russia	82	13	1966
Turkey	82	14	1984
Papua New Guinea	56	15	2001
Guatemala	52	16	1998
Portugal	29	17	1994
China	24	18	1981
France	16	19	1984
Ethiopia	7.3	20	1999
Germany	6.6	21	2008
Austria	1.4	22	Unknown
Australia	1.1	23	Unknown
Thailand	0.3	24	Unknown
Total installed capacity	**10709.7**		

Source: Fridleifsson 2001; Bertani 2010; Holm et al. 2010

An interdisciplinary panel at the Massachusetts Institute of Technology believes that geothermal energy can provide a robust, long-lasting option with attributes to complement other important contributions from clean coal, nuclear, solar, wind, hydroelectricity, and biomass (Massachusetts Institute of Technology 2006). With the worldwide increase in demand for energy in mind, geologists, economists, and planners are promoting geothermal resources as an important source for carbon-neutral energy development (Lund & Freeston 2000; Ghomshei et al. 2005; Massachusetts Institute of Technology 2006; Lebel 2009; Grasby et al. 2011).

Geothermal resources have provided commercial base-load electricity around the world for about a century (Fridleifsson 2001; Bertini 2010; Holm 2010). This resource has been in use in Larderello, Italy, for electricity generation since 1904, with other reported installations around 1916 (Fridleifsson 2001; Bertini et al. 2006; Bertani 2010). In 2010, over 10 000 MW of world energy supply was derived from geothermal sources (Table 2). In the same year, the United States produced over 3000 MW of its energy from geothermal sources. Nevertheless, these resources have been ignored in the country's national energy supply projections because of the widespread perception that geothermal resources are only associated with high enthalpy systems, of which there are relatively few to make an impact at the national level (Massachusetts Institute of Technology 2006). This perception has led to an undervaluation of geothermal resources in the United Sates and, perhaps, internationally as well.

Like other power-plant developments, geothermal projects require a relatively large initial capital investment (Gunerhan et al. 2001). Moreover, geothermal resource developments typically do not enjoy government subsidies such as those available for fossil fuel and hydroelectric power (Allen et al. 2000; Lebel 2009). In addition, annual operating costs could include a reinjection scheme when the underground reservoir exhibits insufficient natural recharge of (Massachusetts Institute of Technology 2006). Despite these costs and lack of subsidies, several countries around the world use geothermal resources for electricity production (Table 2). Indeed, for British Columbia, the comparison of energy resource options in Table 3 shows that the estimated cost per megawatt hour for geothermal technologies and large hydroelectric dams is similar (Table 3). The time estimates for the construction of geothermal energy developments, once the resource is proven, are also comparable to other resource options. Grasby et al. (2011) reported that the average exploration to electricity generation time is about 10 years.

Geothermal resource and community economic development

The oil crisis during the 1970s led to the development of indigenous sources of power in several countries (National Energy Authority and Ministries of Industry and Commerce 2004; Ghomshei et al. 2005). As a result, the Canadian government invested in a geothermal energy program but, unfortunately, the program was terminated in 1986 when energy prices dropped (Lebel 2009; Grasby et al. 2011). This left Canada as the only country along the Pacific "Ring of Fire" yet to develop its geothermal resources (Hickson 2005). As an energy source, geothermal is now promoted as an indigenous, renewable resource capable of reducing dependence on imported fossil fuels and with no storage or backup-power requirements (Allen et al. 2000; Massachusetts Institute of Technology 2006; Grasby et al 2011). Growing awareness of the resource's attributes, including its widespread distribution, sustainability and availability, small ecological footprint, and low greenhouse gas emissions, has increased its profile for sustainable and green energy development.

Table 3: Energy resource options in British Columbia

Technology	Reliability	Estimated costs in $ per MW hour	Greenhouse gas emissions (tonnes per GW hour)	Typical construction time in the United States (years)
Bioenergy	Firm	75–91	0–500	1–2
Coal thermal power	Firm	67–82	0–855	2–3
Geothermal	Firm	44–60	0–10	2–3
Large hydroelectric dams	Firm	43–62	0	6–10
Natural gas	Firm	48–100	0–350	1–2
Small hydroelectric	Intermittent	60–95	0	
Solar	Intermittent	700–1700	0	1–2
Wind	Intermittent	71–74	0	1–2
Tidal energy	Intermittent	100–360	0	Not available

Source: Massachusetts Institute of Technology 2006; B.C. Ministry of Energy Mines and Petroleum Resources 2007

Geothermal energy resources exhibit many advantages over the alternatives. For instance, unlike biomass, fossil fuel, or nuclear energy sources, geothermal energy is location-specific and requires no transportation of raw material from the source of extraction to the power plant. Indeed, Burgess (1989) argued that the potential value of geothermal energy as an indigenous supply for local communities is indisputable, particularly for unindustrialized countries with small energy demands. Grasby et al. (2011) also believed that isolated and remote communities in Canada, which depend on diesel for all their energy needs, could benefit from geothermal resource development.

This energy source is also not subject to intense land use competition because it does not compete directly with agricultural land for food production, as is seen in some biomass energy developments (Kousis 1993; Rajagopal et al. 2007). Furthermore, its development does not encourage the diversion of food crops into energy production, as is seen with corn, which is now used for biomass energy development (Rajagopal et al. 2007). In addition, the geothermal energy source is contained underground, with a relatively compact surface conversion system, and therefore resource development does not require mining material from subsurface or altering the Earth's surface (Massachusetts Institute of Technology 2006; Grasby et al. 2011).

Access to the grid can be an important economic constraint to developing geothermal energy in areas not served by high-capacity transmission lines (Grasby et al. 2011), and, indeed, the lack of economic infrastructure in some regions is currently a barrier to development. Nevertheless, developing geothermal resources in rural and remote areas, both for power production and direct use, could offer an important means to diversify the economic base and potentially contribute the single, largest capital investment in such areas, thereby leading to improved infrastructure and also providing stable, long-term economic and social benefits for these communities (Kagel 2006; Grasby et al. 2011). Socio-economic benefits associated with geothermal resource developments include migration of new skills into the area, reductions in unemployment and associated health problems, increases in the tax base for the local governments, and the development of human resources (Rose 1980; Kagel 2006). Geothermal resource development typically creates long-term jobs, including welders, mechanics, pipe fitters, plumbers, mechanics, electricians, carpenters, geologists, food-processing specialists, spa developers, HVAC technicians, and resort managers (Kagel 2006; Jennejohn 2010). Other potential stimulants to regional income involve associated economic spin-offs, such as those related to local greenhouse food production, district heating for homes and businesses, fish hatcheries, spas, and medical applications (balneology) (Rose 1980; Canadian Geothermal Energy Association 2012; Lund 2010; Grasby et al. 2011).

Reported environmental impacts of geothermal resource development

Although the impact of geothermal resource developments on the environment may not be very obvious, it exists nonetheless. Reported impacts from geothermal resource development include gaseous emissions, water pollution, solid emissions, noise pollution, induced seismicity, and induced landslides and subsidence (Kousis 1993; Welch et al. 2000; Kim et al. 2005; Massachusetts Institute of Technology 2006). Moreover, ecosystem impacts may include water use; disturbance of natural hydrothermal manifestations; thermal pollution; and disturbance of wildlife, vegetation, and scenic vista (Massachusetts Institute of Technology 2006). For example, because of the chemical composition of volcanic rocks and the deeply circulating thermal waters, arsenic may be a constituent of geothermal water, and rapid evaporation of this water can contribute to the high concentrations of this element in some locations (Welch et al. 2000). However, these environmental impacts are site specific, and will depend on the area's ecosystems and regional geology.

A comparison of environmental impacts for different energy sources with the same energy-output shows that geothermal systems have a lower surface footprint (Massachusetts Institute of Technology 2006; Grasby et al. 2011). Table 4 compares typical land requirements for different power-generation options (Massachusetts Institute of Technology 2006).

Table 4: Comparison of land requirements for different power-generation options

Technology	Land use (m^2/MW)	Land use (m^2/GWh)
56 MW geothermal flash plant (including wells and pipes)[a]	7460	900
2258 MW coal plant (including strip mining)	40 000	5700
670 MW nuclear plant (plant site only)	10 000	1200
47 MW (average) solar thermal plant (Mojave Desert, Calif.)	28 000	3200
10 MW (average) solar PV plant (southwestern United States)[b]	66 000	7500

Notes: a) Wells are directionally drilled from a few well pads; b) Excluding rooftop panels in urban settings. Source: Massachusetts Institute of Technology 2006

During the energy crisis in the1970s, Greece started a geothermal energy pilot project as part of its exploration of renewable energy research and development. The objective of the project was to build a 2 MW power station on the Island of Milos, co-funded by the country's Public Power Cooperation, the European Commission, and some European companies. Kousis (1993), in a case study of this project, outlined several of the difficulties it faced. For instance, the geological, ecosystem, and landscape management implications associated with the development for this project were not considered, neither was an environmental impact assessment carried out before the project commenced. Pressures caused by drilling to 1100 m led to a sudden release of 318°C geothermal steam rising 50 m in height and dispersing stones and "mud" over a radius of 1 km, with a lava stream burning everything in its path until it reached the sea. The local people reported impacts of geothermal activities on the physical environment, the agricultural crops, livestock, and human health. Hydrogen sulphide emissions from the pilot geothermal power plant made grain stalks tall but hindered the growth of grain, and caused olive trees in areas adjacent to the pilot project to dry out. The inhabitants suffered from a reduction in their grain crops, and neighbouring islands refused to purchase produce from the area because they feared radioactive contamination from the geothermal effluence. The airborne emission of hydrogen sulphide from the geothermal power plant was believed to have caused respiratory problems, intense headaches, and the tendency to vomit in several people living on Milos in 1988. Chickens and birds were reported to have died as a result of these emissions.

The Greek project clearly shows that site-specific impacts of geothermal development can result in adverse environmental effects on both humans and birds. A detailed environmental assessment of the project later revealed that these impacts were attributed to the volcanic geology of Milos and the technology used (Kousis 1993). The geothermal vapour released contained arsenic and the power plant emitted hydrogen sulphide at more than 20 times the international limit, resulting in the observed health impacts. The plant was subsequently shut down in the autumn of 1992. This case highlights that environmental problems associated with geothermal resources are typically concentrated in the resource extraction zone because of the site-specific nature of the resource, causing discontent among local inhabitants and leading to emotional opposition of resource exploitation by "outsiders" (Rose 1980).

Water is absolutely essential in geothermal resource development, but if open circulation systems are used, groundwater can become degraded. For example, the introduction of shallow water into deeper fractures has caused degradation of groundwater at the Onyang Spa in Korea, as well as at spas in Nevada and Memphis in the United States; near-surface water was also found to degrade and contaminate deeper waters in these areas (Kim et al. 2005). The Massachusetts Institute of Technology (2006) panel concluded that closed-loop circulation geothermal systems can provide environmental benefits by reducing greenhouse gas and other emissions, and can also reduce impacts such as arsenic accumulation, and groundwater contamination or degradation.

Geothermal energy and ecological footprint

Although geologists may characterize geothermal energy developments as having relatively small footprints, a typical site consists of exploratory wells for numerous temperature gradients to measure subsurface temperature, deep slim-hole wells, several full-diameter wells, areas for the drill rig, a holding pond for water to quench potential well blowouts, a service yard for storage of equipment, and access roads (Griffith et al. 2002; Meager Creek Development Corporation 2004). Pipelines and vessels are required to transport steam from the well-heads to the power plant, and transmission lines are needed to transmit the produced power from the power plant to substations (Meager Creek Development Corporation 2004). As geothermal resource development typically occurs in areas of critical habitats, ecosystem management at the landscape level is very important.

Environmental impact assessment is essential to identify and mitigate impacts of development on vegetation, wildlife, and their habitats (Environmental Assessment Office

2005). Important landscape parameters, such as edge and patch sizes, should also be included in the assessment because land clearing for roads, transmission lines, and development can create openings for exotic-species invasions into adjacent vegetation (Griffith et al. 2002). Controlling edge effect also is critical in British Columbia, where many of the sites identified for geothermal resources are in the natural state, and are within the traditional territories of First Nations people (Fairbank & Faulkner 1992). Moreover, in areas of geothermal manifestations in the province, Grasby et al. (2011) identified some ecologically sensitive and rare species that are either protected under the auspices of the Committee on the Status of Endangered Wildlife in Canada or the *Species At Risk Act* and are classified as "endangered" or "at risk." A separate social impact assessment would help identify and mitigate potential infringements on First Nations sustenance rights and potential impacts on sacred and archeology sites (O'Faircheallaigh 1999; Barrow 2002).[2] First Nations people continue to rely on activities such as hunting, trapping, fishing, and gathering berries and medicinal plants for their sustenance and are particularly concerned about developments that could potentially change landscapes or alter ecosystems. Developments of new transmission corridors are likely to affect these sustenance rights and could potentially infringe on First Nations cultural activities (Meager Creek Development Corporation 2004).[2,3,4,5]

The "hotspot" that feeds the Anahim Volcanic Belt in British Columbia is similar to that which feeds the Hawaii Islands (Grasby et al. 2011). For a hypothetical development on the Island of Hawaii, Griffith et al. (2001) compared the effects of disturbance and natural lava flow using GIS techniques. This study showed that the ecological effect of condensed versus dispersed development was important in Hawaii because of problems posed by the invasion of exotic species. The loss of a native plant canopy can result in a greater number of introduced birds at the expense of the native ones (Griffith et al. 2002). Despite British Columbia's more diverse array of ecosystems, which support a greater variety of plant and animal species, similar ecological effects could be experienced here. Invasive species can alter ecosystem processes and the availability of food and medicinal plants upon which First Nations people rely.

Grasby et al. (2011) pointed out that the actual amount of surface area disturbance by the geothermal development can vary from 10% to 50% of the total development area; however, long transmission corridors can lead to the direct removal of native plant canopies by humans, compounded by natural dieback, which can result in large openings for a considerable time period as described by Griffith et al. (2002). The effects of fragmentation and changes in size and shape of landscape patches include the conversion of interior forest to edge, reduction in species genetic diversity, the viability of area-sensitive bird species, reduction in species community stability, and the potential invasion and possibly direct attack by non-native species (Griffith et al. 2002). So while geothermal resource development may have a small footprint, the development and maintenance of transmission corridors can change landscape patterns in relatively undisturbed areas. In addition, cumulative impacts may be missed by a single project, but the combined impacts from access roads, transmission lines, and other unrelated projects may damage a natural or sensitive area over time (Stoffle et al. 2008).

Geothermal resource development in Canada

Canada is rich in natural resources, with oil and gas resource development accounting for a significant proportion of the country's gross domestic product. Canada is also rich in geothermal sources (Figure 2), with high enthalpy resources available in British Columbia and the Yukon, and medium temperature resources present in British Columbia, the Yukon, Alberta, and the Northwest Territories; hot, dry rock resources, which could be used for power production, are also available in the Atlantic Provinces (Ghomshei et al. 2005; Grasby et al. 2009, 2011). The country also has an abundance of thermal springs, with over 150 hot springs having temperatures up to 80°C; approximately 110 of these occur in British Columbia (Ghomshei et al. 2005). The presence of thermal springs and geysers at the Earth's surface does not always guarantee an exploitable geothermal reservoir, but neither does the absence of surface thermal manifestations imply a lack of geothermal reservoirs (Burgess 1989). The province has a significant number of surface thermal manifestations (Figure 1), some of which are under consideration for energy development (e.g., the high temperature system at Nazko, South Meager, and Knights Inlet) Western Economic Diversification Canada 2008; Canadian Geothermal Energy Association 2012). The South Meager project has a potential development capacity of over 100 MW and a probable capacity of 200 MW (Meager Creek Development Corporation 2004; Environmental Assessment Office 2005). The potential development capacity for the Nazko and Knights Inlet areas is yet to be determined, but these resources have been confirmed. If these sites were developed, either for direct use or power production, then it could potentially ease some of the anticipated shortfall in energy supply for the province and provide jobs for the local First Nations.

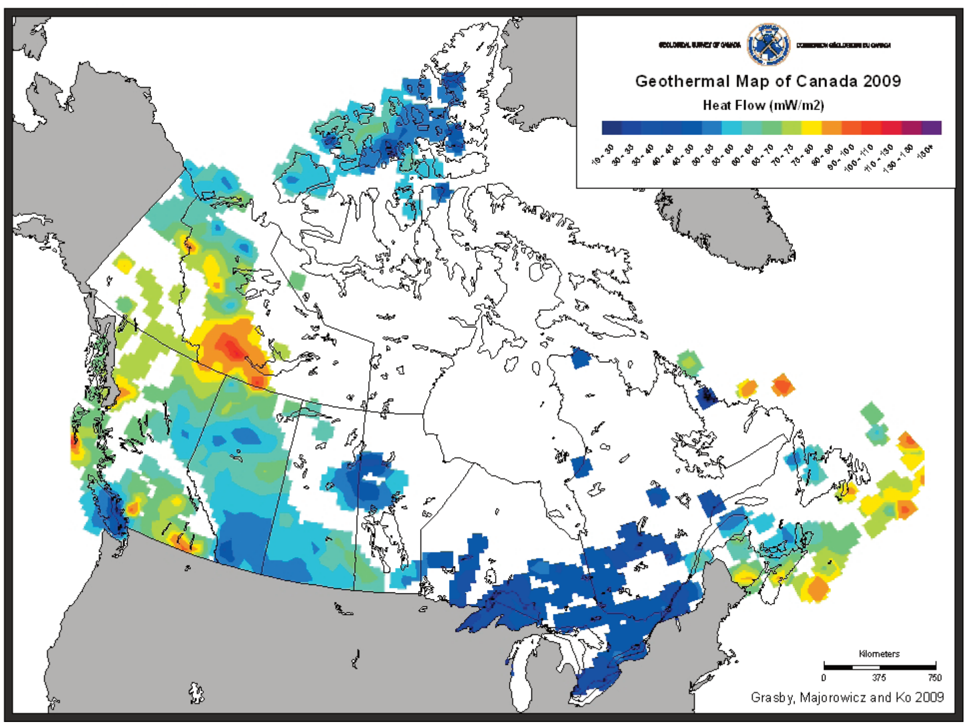

Figure 2: Geothermal map of Canada   Source: Grasby et al. 2009

The Western Canada Sedimentary Basin, which stretches from the Rockies in the west through Alberta and Saskatchewan (Figure 2), is the most studied geothermal system in Canada (Fairbank & Faulkner 1992; Allen et al. 2000; Ghomshei et al. 2005). With deep circulating lukewarm to warm waters and temperatures reaching between 150°C and 200°C at depths of 6.5 km in some areas, this basin is one of the largest accessible geothermal resources in Canada (Fairbank & Faulkner 1992; Allen et al. 2000; Ghomshei et al. 2005; Grasby et al. 2011). Other accessible resources, such as the Canadian Cordillera and the southern part of the Mackenzie Corridor, are equally promising (Grasby et al. 2011). The comparatively low costs of hydroelectricity and fossil fuels in Canada, however, have had a restraining effect on levels of exploration and development of alternative energy resources (Allen et al. 2000). With the pressure to reduce fossil fuel extraction at the controversial oil sands in Alberta, these geothermal resources could provide alternative green energy development.

Despite the unsubsidized, high cost of development, some geothermal exploration activities have occurred around the country. Table 5 shows the location of several ongoing projects and their developers.

Table 5: Geothermal projects in Canada

Project	Developer	Location	Status
Pebble Creek	Tecto Energy Inc. & Alterra Power	British Columbia	Under development
Canoe Reach	DeepRock Geothermal Inc.	British Columbia	Under development
Knights Inlet	Ram Power	British Columbia	Under development
South Meager	Ram Power	British Columbia	Under development
Swan Hill	Borealis Geopower	Alberta	2 MW project from waste heat
Ft. Liard	Borealis Geopower	Northwest Territories	Feasibility study for 1 MW pilot project
Con Mine	City of Yellowknife	Northwest Territories	Project not supported by community despite federal government funding

Sources: Canadian Geothermal Energy Association 2012; Íslandsbanki Geothermal Research 2010; Ghomshei, 2010

Low temperature geothermal resources are being used around the country for heating and cooling small units, commercial buildings, and larger private homes. Examples of these include the heating and cooling system at the University of Northern British Columbia's regional campus in Quesnel, the Carleton University campus in Ottawa, the Sussex Hospital in New Brunswick, and the Scarborough Centre in Toronto (Allen et al. 2000; Ghomshei et al. 2005). Groundwater from wells is being extracted for heating or cooling many large facilities, including the Vancouver International Airport and the Sandspit Airport on Haida Gwaii (Allen et al. 2000). Communities such as Golden and Yellowknife are also considering the use of geothermal energy for district heating. Other uses of geothermal resources in Canada include hot spring resorts such as those found in Jasper, Banff, Whitehorse, Terrace, Kootenay, and Revelstoke (Ghomshei et al. 2005; Canadian Geothermal Energy Association 2012). These resorts use geothermal waters in spas and pools. There are also over 90 wilderness springs around the country, many of which are undeveloped and left in their natural state.

Geothermal resource development challenges in British Columbia

To meet its growing energy needs, both for internal consumption and export demands, and to achieve its energy policy goals, the British Columbia government is encouraging development of alternative energy resources (B.C. Ministry of Energy Mines and Petroleum Resources 2007; Lebel 2009). The scale and severity of the mountain pine beetle infestation in the province has resulted in an increase in biomass energy development. Solar and wind energy developments are also on the rise. Geothermal energy, while viable and within reach, remains largely untapped (Ghomshei et al. 2005; Lebel 2009). Development of this resource in British Columbia faces several challenges. The high risk of exploration related to the cost of deep drilling and the availability of resources outside of high-capacity transmission lines are key economic constraints (Grasby et al. 2011).

Some identified geothermal locations in British Columbia are within traditional territories of First Nations communities. Developing transmission corridors several kilometres long (e.g., the 136 km line proposed for the Mount Meager project) can be problematic because of ongoing land claims and the identified subsistence rights of First Nations people (Meager Creek Development Corporation 2004; Environmental Assessment Office 2005). A legal obligation exists to consult with First Nations communities before undertaking any development that could potentially affect their traditional hunting, fishing, trapping, and gathering activities.[2,3,4,5] However, the Nazko First Nation in the Central Interior is seeking to develop the geothermal resource within its territory (Western Economic Diversification Canada 2008). First Nation communities have spatial and temporal social impact assessment needs (O'Faircheallaigh 1999; Barrow 2002; Summerville et al. 2006; Stoffle et al. 2008), which can be identified and mitigated at the early stages of a project; however, no separate social impact assessment process is currently available in British Columbia.

Some member companies of the Canadian Geothermal Energy Association are based in Canada but have energy projects in other countries (Canadian Geothermal Energy Association 2012). Hidden government subsidies directed at hydroelectricity and fossil fuels have provided little incentive for these companies to develop the geothermal resource in Canada (Lebel 2009). No provincial governmental organizations support geothermal energy research, and national funding for research on low temperature geothermal energy has declined (Allen et al. 2005; Lebel 2009). British Columbia is the only jurisdiction in Canada that regulates geothermal resources and the associated exploration activities (Íslandsbanki Geothermal Research 2010). The B.C. Ministry of Energy and Mines has the authority to administer geothermal rights and issues these rights through a competitive public tender process (Íslandsbanki Geothermal Research 2010). Geothermal leases are granted for a 20-year period, after which they can be renewed, but perhaps it would be beneficial for both investors and communities if these leases were awarded for the lifespan of a facility. First Nations people, however, can develop geothermal resources on their reserve lands as these do not come under provincial jurisdiction. The ecological footprint of a geothermal resource project, if properly considered, make this type of energy development more compatible with First Nations' interests and could potentially provide sustainable economic and social benefits for their communities.

Conclusion

British Columbia has an abundance of geothermal resources, with some manifestations of these in rural and remote communities. The development of these resources presents opportunities for the diversification of economic base and can complement other uses of forest lands. Direct use, such as local greenhouse food production, fish hatcheries, and spa resorts, can stimulate regional income with sustainable socio-economic benefits. The indigenous nature of the resource means that these benefits would remain within the region where the resources are located.

Isolated and remote communities that depend on diesel for all their energy needs could benefit from geothermal energy development. This type of development requires drilled wells, which do not modify the Earth's surface to the same extent as the strip mining of oil sands or coal. The sustainability of this renewable resource makes it an ideal choice for indigenous power production, and the jobs created are long term and stable.

The minimal discharges that result from geothermal resource development are site specific and can be identified during environmental impact assessment processes, with potential mitigation possible before development takes place. A detailed environmental impact assessment can also identify areas with ecologically sensitive or protected species. New transmission corridors to bring power to regional grid may create economic and social constraints on project development. However, an independent assessment of social impacts should be conducted before project approval and development to help identify and mitigate the spatial and temporal needs of First Nations people.

The modest land use and small ecological footprint still makes geothermal energy a more environmentally friendly source of alternative energy, one that has a proven ability to offset increasing emissions of carbon dioxide and other greenhouse gases. Targeted government subsidies are especially needed to encourage this type of resource development in rural and remote areas that currently depend on diesel fuel for their energy requirements. Moreover, this type of energy can be developed in less than 10 years, thereby helping to achieve the British Columbia government's goal of electricity self-sufficiency by 2016 and alleviating the projected shortfall in energy supply.

Notes/Websites

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Author information

Titi Kunkel – PhD candidate, Natural Resources and Environmental Studies program, University of Northern British, South Central Regional Campus. S100–100 Campus Way, Quesnel BC V2J 7K1. Email: kunkel@unbc.ca

Dr Mory Ghomshei – Adjunct Professor at McGill University and The University of British Columbia, Mining Engineering. 5th Floor, 6350 Stores Road, University of British Columbia, Vancouver BC V6T 1Z4. Email: mory@interchange.ubc.ca

Professor Robert Ellis – Dean, Faculty of Management, University of Lethbridge. 4401 University Drive, Lethbridge AB T1K 3M4. Email: robert.ellis@uleth.ca

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Test your Knowledge

How well can you recall the main messages in the preceding article?
Test your knowledge by answering the following questions.

Geothermal Energy as an Indigenous Alternative Energy Source in British Columbia

1. How many geothermal power plants are currently operating in Canada?
   - a) Zero
   - b) One
   - c) Two

2. Which Canadian province regulates geothermal resources and exploration?
   - a) Alberta
   - b) Ontario
   - c) British Columbia

3. Which country on the Pacific "Ring of Fire" is yet to develop its geothermal resource?
   - a) Canada
   - b) England
   - c) Spain

ANSWERS: 1=a; 2=c; 3=a