The Techno-Economic Feasibility of a Geothermal District Heating System in Chateh, Alberta

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Summary

In line with global decarbonizing goals from *COP26*, Canada pledged a 40–45% reduction by 2030 from 2005 emission levels. One piece to achieve this is transitioning building heating to zero-carbon energy sources, as it represents 60% of a building's total energy use. Geothermal energy is a renewable resource providing heat energy from the Earth. This project focuses on the feasibility of developing a geothermal district heating system in Mackenzie municipality, focusing on the Dene Tha' reserve in Chateh township, a shallow high-temperature anomaly in Western Canada Sedimentary Basin, and compares this to current heating sources: natural gas and diesel. RETscreen will be used to run the techno-economic analysis using parameters from numerical simulations, including expected building energy demand, literature values, and government surveying data, including local geology, oil and gas operations and existing infrastructure. Geothermal has a strong undeveloped potential, and investing in clean energy is essential for the reconciliation of Indigenous peoples. The project will propose Indigenous ownership models, aligning with the *Corporate-Indigenous Relations Council's* goal of increasing Indigenous involvement in Canada's energy sector.

Theory / Method / Workflow

The project examines the techno-economic feasibility of geothermal energy to supply district heating for Chateh township, located in northwest Alberta in the Western Canadian Sedimentary Basin (WCSB).

Space and water heating is the dominant energy demand for residential and commercial buildings, representing over 60% of energy usage by buildings in Canada. Natural gas-powered furnaces are the predominant building heating systems in Alberta. A typical household (~3 persons) uses 130 GJ natural gas/year, emitting 12 MT CO_2/year. *Canada's Strengthened Climate Plan* aims to reduce the CO_2-eq emissions up to 30% from 2020 levels by 2030, on the path to achieving a net-zero carbon economy by 2050. Areas with high undeveloped geothermal potential can be found in Northwestern Alberta, offering rural municipalities an opportunity to leave a strong legacy for the Canadian energy sector (Wilson-Layton, 2018; Majorowicz and Grasby, 2020; Government of Canada (GoC), 2021b).

Alberta is uniquely positioned to reach long-term success in the geothermal industry due to the maturity of drilling, completions and production services, subsurface stability, and the potential to pivot the expertise of displaced oil and gas workers (Leitch, Hastings-Simon, & Haley, 2017; Powel, 2020).

Chateh is located in a high heat geothermal anomaly, with the most elevated shallow depth temperatures in Alberta, allowing for diverse end-development applications (see Figure 1) (Nieuwenhuis et al., 2015; Northern Alberta Development Council, 2019; Majorowicz and Grasby, 2020). Similar geothermal applications have been completed internationally, such as the Paris basin domestic water project, and nationally, with Edmonton's Blatchford Field shallow geothermal project, also known as geo-exchange, for community heating (Richter, 2020; Blatchford Renewable Energy, n.g.).

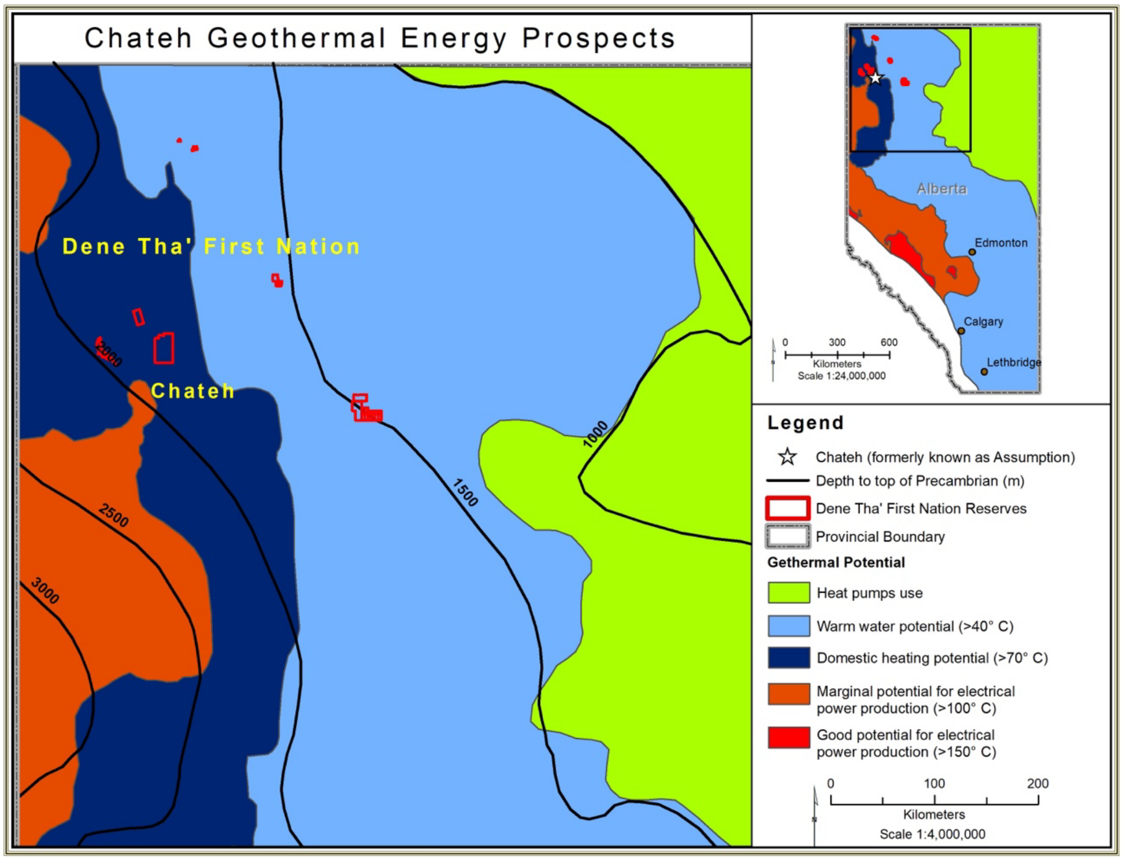

Figure 1. Chateh geothermal energy prospects.
Note: The map is adapted from Majorowicz & Grasby, 2020.

Chateh community falls under Treaty 8 Land and has a population of ~950 people (Statistics Canada, 2015). Chateh is one of three Dene Tha' First Nations (DTFN) communities. In the past several decades, forestry, as well as oil and gas industries, have experienced accelerated growth and development in DTFN traditional lands (Horwath et al., 2002). In particular, the areas north and south of Chateh have the highest development and concentration of these industries in the WCSB. Despite these industries' rapid growth on the traditional lands and their consequent contributions to Alberta's economy, the DTFN has not received these economic benefits. The DTFN peoples continue to experience below the Canadian average living conditions and are estranged from their land (Horwath et al., 2002).

Additionally, the DTFN, like many other Indigenous communities, are disproportionately affected by climate change facing a particularly severe infrastructure deficit (GoC, 2021; Corntassel, 2012). The energy transition towards renewable sources is a potential pathway to reconciliation (Mcgregor, 2019; Scott, 2020). Currently, the DTFN are attempting to rebuild their culture and become involved in resource planning and management, to control and benefit from the resource development on their traditional land (Horwath et al., 2002).

Alberta communities within Mackenzie County, including Rainbow Lake, Zama City, Chateh and the Buffalo and Peace River Basin communities, collectively contribute a minimum of 50 kT CO_2 eq/year (Environment Canada, 2015). In these communities, the primary heating sources are natural gas and diesel fossil fuels, which are also more expensive due to higher transmission fees. Several climate change effects are already being experienced by the communities, including annual ice breaks and flooding, changing the aquatic environment necessary for sustenance, as well as forcing the DTFN members to leave their homes (Wrona et al., 2006; European Environment Agency, 2012; The Canadian Press, 2016).

Due to the cold climate, Chateh requires year-round heating (WeatherSpark, 2021). Heating degree days (HDD) represent the amount of heat in degrees Celsius needed annually; for each day, average temperatures fall below 16 °C (Environment and Climate Change Canada, 2021). Chateh has 6412.3 HDDs, the highest value in Alberta and significantly more significant than the ~4100 HDD National average (NAIMA Canada, 2021; Climate Atlas, n.g.). A geothermal district heating network will help reduce ~2500 T CO_2-eq/year, calculated using an estimation from Statistics Canada (2018) and Majorowicz and Grasby (2020).

For district heating, a geo-exchange system will be used. These operate at depths <400 m and temperatures <40°C, taking heat from ground-source heat pumps in the winter for heating and transferring heat into the ground during summer for cooling (Powel, 2020). These systems are efficient and can service residential, commercial and light industrial buildings, reducing operational costs and aligning with provincial and federal renewable energy goals. In addition, geothermal development will create meaningful employment and upskill displaced oil and gas workers for the growing green sector (Wilson-Layton, 2018).

A district energy heating system is a heat distribution system for multiple buildings in a block region. The establishment of district energy uses economies of scale to minimize the operating cost by servicing numerous facilities and minimizing the equipment's initial capital investment (Carou, 2016). Building proximity and density are the main challenges of district heat transport, requiring important buildings to be within a 1.5 km radius of each other (Figure 2) (Harvey, 2006).

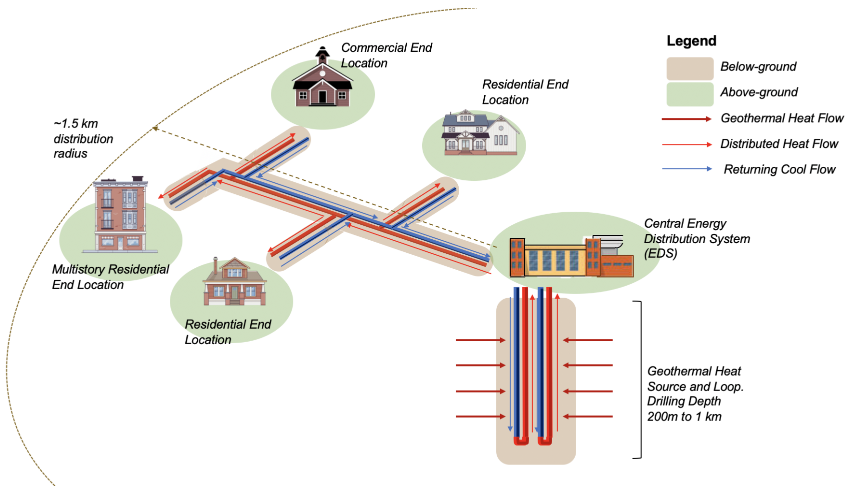

Figure 2. Schematic of District Heating System servicing Commercial and Residential Buildings, using Geothermal Heat as Energy Source.

Results, Observations, Conclusions

The techno-economic feasibility analysis will drive the Chateh district heating project's suitability. The techno-economic analysis will include assessments of developments, such as well drilling, plant and well site construction, well pumps, lateral piping, ground source heat pump and Electrical Transmission System (ETS) installation, costs of connecting with existing energy infrastructure, as well as Engineering and Environmental fees (Geoscience BC, 2019). The analysis will also consider Federal and Provincial funding and resource allocation opportunities through sustainability programs, tax incentives, development density bonuses, efforts toward lower permitting costs and land discharge fees (Solbak, 2016). Existing oil and gas wells will be considered to reduce initial capital costs and the environmental impact.

The techno-economic assessment will be calculated using RETScreen to understand the project's viability and lifecycle processes (GoC, 2021c; National Renewable Energy Laboratory, 2020).

To obtain parameters for the techno-economic analysis, provisional use of geoSCOUT software will be used to provide detailed geology, subsurface activity and profile reports on existing wells in the focus area. Numerical simulations will be used to determine the energy demand of existing infrastructure, using *Natural Resources Canada* (*NRCan*) software HOT2000 to model the building conditions, informed by the *Alberta Building Code* (*ABC*) and determine the district heating system placement (NRCan, 2018). Figure 3 summarizes the main aspects of the techno-economic analysis of a geothermal district heating system.

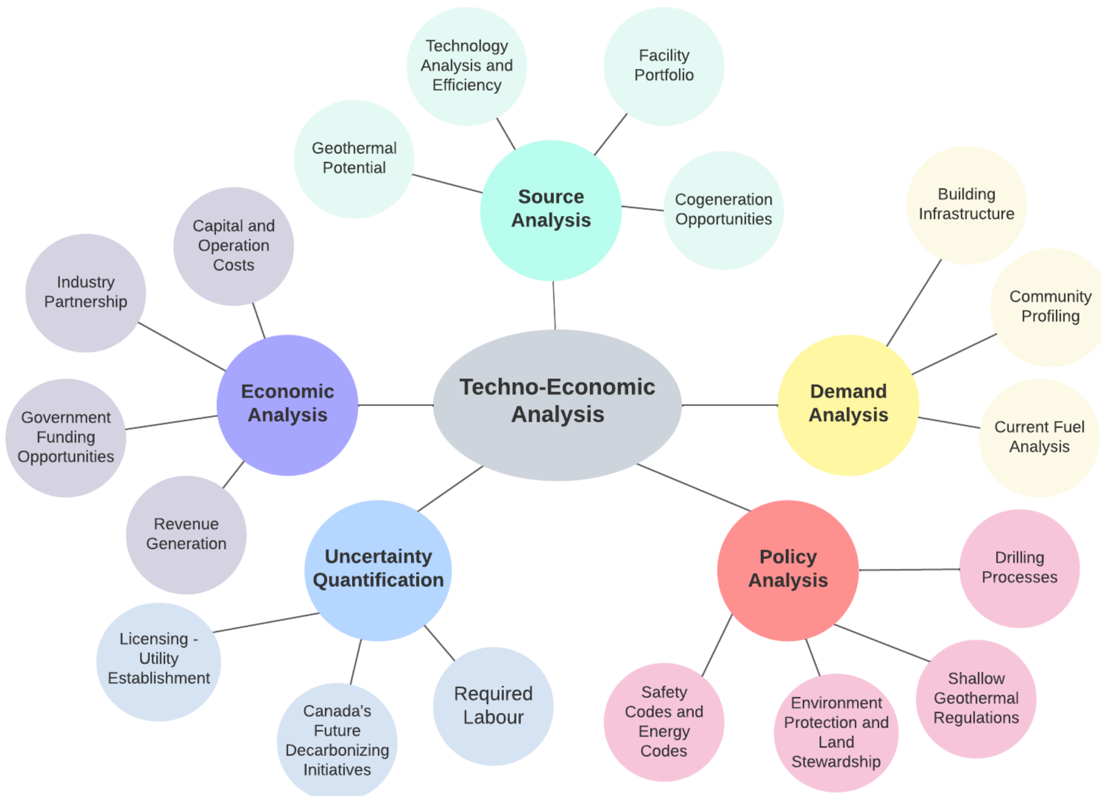

Figure 3. Summary of Geothermal District Heating Techno-Economic Analysis Areas

Novel/Additive Information

The *United Nations Climate Change Conference* (*UNFCCC*) *COP26* in November 2021 produced new pledges at global, national, and corporate scales to combat climate change. Canada's *COP26* commitment was strengthening the *National Climate Plan* to reduce emissions by 40–45% from 2005 levels by 2030, achieve net-zero by 2050 under the *Canadian Net-Zero Emissions Accountability Act,* and support developing countries by doubling international climate finance (GoC, 2021a).

In 2021, Alberta Indigenous Opportunities Corporation Act created a Crown corporation - the Alberta Indigenous Opportunities Corporation (AIOC), to support Indigenous investment in natural resource development and infrastructure (CBC News, 2019; Vitello, 2019). The corporation provides loans of up to $250 million to Indigenous groups, aiming to help them develop sustainable energy projects, including oil and gas, renewable energy, and power (Alberta Indigenous Opportunities Corporation, 2022). By providing this funding, the sustainability sector has an opportunity to experience growth and innovation, and by explicitly focusing on Indigenous communities, funds are now available to groups who were historically excluded from such development opportunities.

Our work will explore a meaningful partnership with the DTFN through Indigenous ownership models of the proposed district heating system. Our work will explore a bottomup approach to involve the DTFN in ownership and control of energy generation, retail, distribution and demand management (Campney, 2019). The DTFN currently has an innovative water-treatment plant, designed and wholly owned and operated by the community (ISL Engineering and Land Services, 2011). This water-treatment plant is an integral part of the community and a successful example of industry partnership with the DTFN community. We envision a similar geothermal district heating implementation and using the new funding mentioned above opportunities.

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- The Treaty 6 territory and a traditional meeting ground and home for many Indigenous Peoples, including Cree, Saulteaux, Niisitapi (Blackfoot), Métis, and Nakota Sioux.
- The Treaty 7 region in Southern Alberta, including the Siksika, the Piikani, the Kainai, the Tsuut'ina and the Stoney Nakoda First Nations, including Chiniki, Bearpaw, Wesley First Nations, and Métis Nation of Alberta, Region III.
- The traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River.

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