Techno-Economic Assessment of Geothermal Energy Resources in the Western Canada Sedimentary Basin, Northeastern British Columbia

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Introduction

To date, no commercial geothermal electric power plant has been successfully developed in Canada. Much of the research and development activities in British Columbia (BC) have concentrated around the high-temperature volcanic geology of the Mount Meager complex, but these have yet to yield a commercial power plant. The Western Canada Sedimentary Basin (WCSB) in northeastern BC has received less attention, in part due to its lower temperature resource. However, this region has been subject to substantial oil and gas development, and a significant amount of data from drilling activities is available (Grasby et al., 2012). This data has been successfully applied to estimate the electric power potential for a project in the Clarke Lake gas field (Walsh, 2013). In this study, this data is applied to a broader region to assess the potential and the cost for geothermal power plants in the WCSB within BC (Figure 1).

The latest, most comprehensive techno-economic study of geothermal resources in BC was recently released by Geoscience BC (Kerr Wood Leidal Associates Ltd., 2016). Here, 19 sites were pre-evaluated for their feasibility, taking into account factors like distance to transmission and road access, as well as a number of other parameters. The 11 favourable sites were evaluated in detail for technical and economic potential. The volume method (Williams et al., 2008) was applied to assess the potential electric power. Further, the Geothermal Electricity Technology Evaluation Model (GETEM) was applied to assess the levelized cost of electricity (LCOE) for each project. Two of the projects assessed in this study are located in the WCSB, namely Clarke Lake and Jedney (Figure 1). Their projected LCOE was $297 per megawatt-hour (MWh) and $398/MWh, respectively, higher than any other project in the study.

Since the release of this study, a number of questions have been raised regarding the assumptions that led to the assessed LCOE values. For example, drilling costs were based on the situation in 2012, a boom year for the oil and gas industry. Since then, the significant decline of oil and gas prices has caused drilling costs to drop considerably. A decrease in this cost item is expected to have a significant impact on LCOE.

Further, the required exploration plan for the sedimentary basin projects may be less elaborate than assumed in the Geoscience BC study. Considering the number of oil and gas wells already existing in the area, it has been assumed that the number of required exploration wells is lower and the success rate of confirmation wells is higher than previously anticipated. This research project will therefore use data from oil and gas exploration (files provided by the BC Oil and Gas Commission) to refine costs for projects in the sedimentary basin.

Methodology

In order to assess the economic feasibility of geothermal power plants in northeastern BC, the first step is to locate those areas where economic feasibility is most likely. A favourability map that takes geological and economic factors into account is created. This map is used to select particular locations that are representative for their geological and economic environment. In the second step, the economic feasibility of a geothermal power plant at those select locations is assessed.

Site Selection

Identifying the most favourable site for a geothermal power plant is a spatial decision-making problem. In this study, an adaptation of the weighted linear combination (Malczewski, 2000; Nyerges and Jankowski, 2009) is employed,

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Figure 1. Project area and two of the potential sites for geothermal development, northeastern British Columbia. Background map created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com.

due to its relative simplicity for dealing with a small number of input criteria. The process (Figure 2) will be implemented in a geographic information system (GIS), such as ArcGIS or QGIS.

The favourability map depicts the favourability score for each grid point within the project area. The score is a measure of the potential economic feasibility of developing a geothermal power plant. A higher favourability score indicates a higher likelihood of a geothermal plant being economically feasible at a particular location. Therefore, several criteria that contribute to geothermal favourability are taken into account.

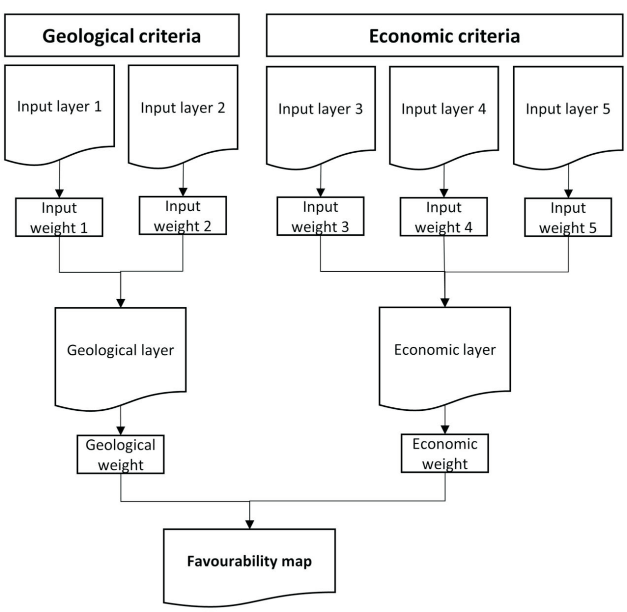

Figure 2. Flow diagram illustrating the favourability mapping process for potential geothermal development site selection.

Geological criteria include temperature and permeable aquifer data. This data will be extracted from drill-stem test logs and records pertaining to natural gas producing fields. It is then filtered for data from strata of the Middle Devonian Elk Point Group, as those strata a) potentially contain aquifers and b) are located at depths that potentially possess a temperature sufficient for binary geothermal power plants (above 80°C). Economic criteria include proximity to electrical infrastructure as well as towns and small communities. Areas where future natural gas extraction is expected to occur will be taken into account as potential sites of geothermal electricity consumption.

Sites at Clarke Lake and Jedney have already been identified as suitable sites for geothermal development (Kerr Wood Leidal Associates Ltd., 2016) and will be investigated within this research. Further potentially suitable sites will be identified, with candidates including Fort Nelson, Dawson, the Horn River Basin and Fort St. John.

Economic Assessment

The objective of the economic assessment is to quantify the amount of energy available, and the cost of that energy, at each of the representative locations selected in the previous section. Focus lies on harnessing electrical energy. The possibility to supply heat energy will be a secondary goal wherever proximity to potential consumers justifies this investigation.

The economic assessment consists of three parts. First, the size of the geothermal reservoirs and their associated power outputs will be assessed using the volume method (Williams et al., 2008). Secondly, literature regarding the economic modelling of geothermal power projects will be reviewed, in order to identify the most suitable model. Thirdly, the most suitable model will be applied to assess the LCOE. Here, appropriate values for the cost of drilling, depreciation of assets, currency conversion and capital costs will be input into the model. Appropriate values will be retrieved from literature as well as recent cost estimates provided by industry. These include

- a class C cost estimate for an organic Rankine cycle geothermal power plant (5 megawatt [MW] output, 110°C fluid inlet temperature), and
- cost estimates for drilling and well completion.

Results from the selected economic model will be compared to at least one other model. Further, the sensitivity of results to varying technical parameters (temperature, flow rate) and economic parameters (drilling costs, drilling success rate, capital costs) will be assessed in a Monte Carlo simulation.

Conclusions

It is expected that several locations, beyond Clarke Lake and Jedney, will be found that are potentially suitable for geothermal development. It is further expected that the LCOE at Clarke Lake and Jedney will be lower in this assessment than previously estimated for Geoscience BC (Kerr Wood Leidal Associates Ltd., 2016). This study will devise a methodology for assessing sedimentary basin geothermal energy by using data from oil and gas exploration. In future work, this methodology can be applied to Alberta, where an additional body of data is available.

Current Status and Project Timeline

The first part of this study, namely site selection via favourability mapping, has been completed to date. Results from this section are still under review and therefore not yet presented here. The second part of the study, the economic assessment, is ongoing. Results of this study will be submitted to a peer reviewed journal by May 2017. After publication, a full report will be released by Geoscience BC.

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