

SUMMARY Resource Options Update:
NOTES Geothermal

July 17, 2015
10:30 – 12:00
BC Hydro Dunsmuir

TYPE OF MEETING	Technical Engagement – Geothermal
ATTENDEES	Justin Crewson (CanGEA), Craig Dunn (Borealis), Mory Ghomshei (UBC) Mike Hopkins (FortisBC), Paul Rapp (Alterra), Timothy Sadlier-Brown, Carlos Salas (GeoscienceBC), Amy Sopinka (Ministry of Energy and Mines), Alison Thompson (CanGEA), Chris Trumpy (Ministry of Energy and Mines), Ron Yehia, Ron Zeilstra (FortisBC) Consultants: Jeff Barker (KWL), Amber Falconer Thomas (GeothermEx)
BC HYDRO	Alex Tu, Randy Reimann, Anne Wilson, Edlira Gjoshe; Dave Ince
OBJECTIVES	Seek input from industry to inform the characterization of the geothermal resource option
AGENDA	<ol style="list-style-type: none"> 1. Review historical work on geothermal in B.C. 2. Describe the scope and objectives of the update 3. Share results of the Economic Assessment study conducted by KWL/GeothermEx 4. Solicit feedback on the assessment
MATERIALS	Presentation slides

MEETING SUMMARY
<p>BC Hydro welcomed participants to the meeting, and reviewed the agenda and objectives of the meeting. Alex Tu walked participants through the slide presentation. The following provides a summary of comments and questions related to the associated slides.</p> <p>Slide 8</p> <p>It was clarified that the first column are the numbers (MW) from the previous assessment.</p> <p>There was a question about exploration uncertainty and whether that was from previous work or if locations were eliminated because there was not information. The consultant described the process of putting together the geothermal development decision matrix. Only publicly available information was used, and each component of the matrix had a number of criteria that needed to be met. With the exploration uncertainty there were five or six items of criteria and some comment, for example: specific timing, degree of exploration to date, and availability of surface area to host operations. There is a summary rating from exploration to exploitation, which is a relative measure of exploration risk to differentiate sites within the study. It is recognized that risk assessment is not an exact science. Included within the report is a discussion of each site and what contributed to the favourability assessment score.</p> <p>Slide 9</p> <p>It was clarified that the cumulative cost value is amount of investment at site to date in relation to the estimated cost it would take to develop the site.</p> <p>It was clarified that in the report, the table on this slide is preceded by a picture of the model from the World Bank handbook for geothermal development.</p> <p>It was clarified that Clarke Lake and Jedney are the two hot sedimentary aquifer sites.</p> <p>A participate asked a question on the criteria for project risk, showing that Meager Creek is high to moderate and Pebble Creek is high. It was clarified that it is largely based on what exploration has been conducted to date and what public information was available to support the risk assessment. Meager creek has had the most public information on drilling, while others do not have public information on drilling. It was pointed out that Pebble Creek has had a number of drilling activities that were the subject of several publications, and perhaps the consultants did not include them in the assessment. It was mentioned, if that data was missed, then it can be passed along to BC Hydro to take a look at.</p> <p>It was also mentioned by a participant that it is possible that area that was referred to Pebble and now it is collated</p>

under Meager creek, which in history has been lumped. Pebble creek has now been changed to Boulder creek. It may be worth going back and confirming the boundary lines.

Slide 11

It was clarified by GeoscienceBC that Jedney was chosen as a site partly due to a study being conducted by Canadian Discovery. The Canadian Discovery project – separate from this current economic viability project – indicated that the Jedney area represented a very favourable example of hot sedimentary aquifer in terms of geothermal development.

Slide 12

A participant questioned what the underlying assumed distribution of the Monte Carlo simulation is. For example, is it a normal distribution? To get this information will need to follow up with the consultant undertaking this analytical work.

It was suggested by a participant that the degree of uncertainty in estimating the volumetric value should be clear and linked with the Monte Carlo estimate. For example, for some sites there is significant data to indicate the thicknesses of reservoir, and for others the area of a reservoir is inferred from locations of hot springs or from more general inferences of similar jurisdictions. The methodology is documented in the appendix of this report. The degree of certainty of the volumetric assessment will be different, e.g., in Meager Creek high degree of certainty, but with others very ambiguous.

It was recognized that for some there is no drilling data available, and the best was done with what was available.

A participant mentioned that it was good to use other global examples, like canoe reach, and using global analyses is a good reference source.

BC Hydro mentioned that it sounded like there have been assessments of volumetric analysis undertaken with a number of papers to come up. BC Hydro would be interested to see it. As well, perhaps some error bars would be wider with some than others.

Slide 15

It was confirmed that all of these assumptions used in this study are outlined in report.

A participant questioned whether there was any reflection in the economic valuation of a credit for deferred transmission investments given to geothermal projects that may provide firm power in locations where it can be used to reduce the peak load. Generally, the consultant stated the transmission line costs were based on a document called Road and Power Line Estimations using GIS. Given a particular size of facility and voltage and terrain type it will give you an estimate. It was not thought that the estimate was down to the level of detail that is behind the question. A credit given to base load power is not reflected in here.

It was confirmed that the Geothermal Electricity Technology Model (GETEM) does not account for the recent down turn drilling availability. The GETEM uses cost estimates of drilling rig rental rates from 2012, and they are available as 'hidden sheets' in the model.

There was a question as to how exchange rate was handled? This study used exchange rate from April 28, 2015, which was 82 cents.

It was asked how much a shift in exchange rate would have on levelized costs. BC Hydro has not run that sensitivity analysis, and could have a quick look at it given today's exchange rate. A participant stated it was worth noting a lot of suppliers are not U.S. based, and that sticking directly to U.S. costs may not be accurate.

It was clarified that the power plant costs reflected in one of the tables is not normalized for plant size, but rather reflects total plant costs.

Permitting and leasing fixed costs were discussed. Permitting and leasing current costs used in this report were based on acreage and a simple multiplier based on global experience, and explained in the Appendix. There is a yearly fee along with application. Regarding soft costs such as community and First Nations engagement and accommodation costs, there is no specific cost estimate of these costs relevant to B.C. There is a half million allocated for each site for environmental costs. Contingencies of 15% were included for all costs, including exploration.

It was mentioned by a participant that soft costs relevant to B.C. should be included. It was suggested that Alterra run-of-river projects would be a good example of the costs and timeline to advance a project. The report's estimate of \$500,000 to capture environmental assessment and First Nations engagement costs would be exceptionally light.

A participant was curious about upfront costs of exploration and resource confirmation costs. Range from 25% to 35% or more total capital costs were derived. The details of this are shown in Appendix for inputs for GETEM. There are different project phases, and in spreadsheet should have a clear separation. The Resource exploration phase includes surveying and leasing but does not include confirmation drilling. The confirmation phase includes production well drilling until 25% of the total heat required for the nameplate capacity has been achieved.

Timeframe for permitting would likely be longer in B.C. than the global average, and so shouldn't use global average in geothermal development.

It was clarified that credit for ancillary services doesn't come into the levelized cost of electricity (LCOE) calculation. Currently no benefit or value assigned to these benefits in the calls.

A participant stated that there has been anything from a 25% to 40% decrease in costs for drilling rig rentals relative to the 2012 cost data used in the report. Is it possible to note that this is the case? BC Hydro mentioned that they were fine noting that. It is probably a fair thing to state, but that also costs fluctuate and it is not going to stay down.

Also drilling penetration and drilling technology has evolved. It was acknowledged and noted by the consultant that this study was developed with the best information at the time.

Slide 16

It was clarified for O&M costs assumption that a percent of capital costs range from \$16/MW hour (Meager Creek) to \$37/MW hour (smaller sites).

A participant stated that a recent EIA study has shown costs from a half to a third of any of the LCOE numbers from this report. Another participant noted that currently using a 20-year life cycle and if that was changes to 30 years it may be more favourable.

A participant wondered if the model was available to us, or can they provide some data for BC Hydro to run. It was mentioned that the model was available to everyone. BC Hydro mentioned if there is a separate request is something that you want to run, to send a note and BC Hydro will take a look at it.

It was mentioned there is a link to the Excel model in the report.

There was a discussion regarding the underlying assumption of success rate for drilling. The GETEM allows for input of assumptions about number of well pads used at the site, confirmation drilling success rates and production drilling success rates. The Appendix indicates the inputs for the model, which are in line with global averages. The participant asked if they sent BC Hydro data if BC Hydro could run portfolios and then send it to the group. It was clarified that BC Hydro does not have any plans to do any additional portfolio runs currently, but will use the updated information. May come out in the future but not part of this project.

A participant commented that the purpose of doing a LCOE analysis so it can be compared with other options. A better way to compare resources is to use Levelized Cost of Avoided Energy with a good description in EIA study – if you were to build the comparable cost – what is the best alternative. BC Hydro shares the idea that a simple number such as LCOE is not that useful, and clarified that when portfolio analysis is undertaken there is a fulsome assessment. BC Hydro shows adjusted unit energy costs and which also includes factors related to capacity impacts and transmission losses.

It was clarified that, within the portfolio runs, capacity factors are taken into account.

It was clarified that combined heat and power projects were not looked at, and that residual sales of heat would improve the economics of projects. Geothermal is a good example for this.

There was a question about a bond to meet demolition costs and whether those were reflected the end of life. It was not clear how demolition costs were treated and whether it was a significant cost factor. A participant commented that with a 20-year renewable life you would have a credit.

BC Hydro closed the meeting with next steps: the report is available at GeoscienceBC website and people are invited to provide feedback over the next three weeks with final comments due August 7.

People were thanked for their participation.

Meeting close.