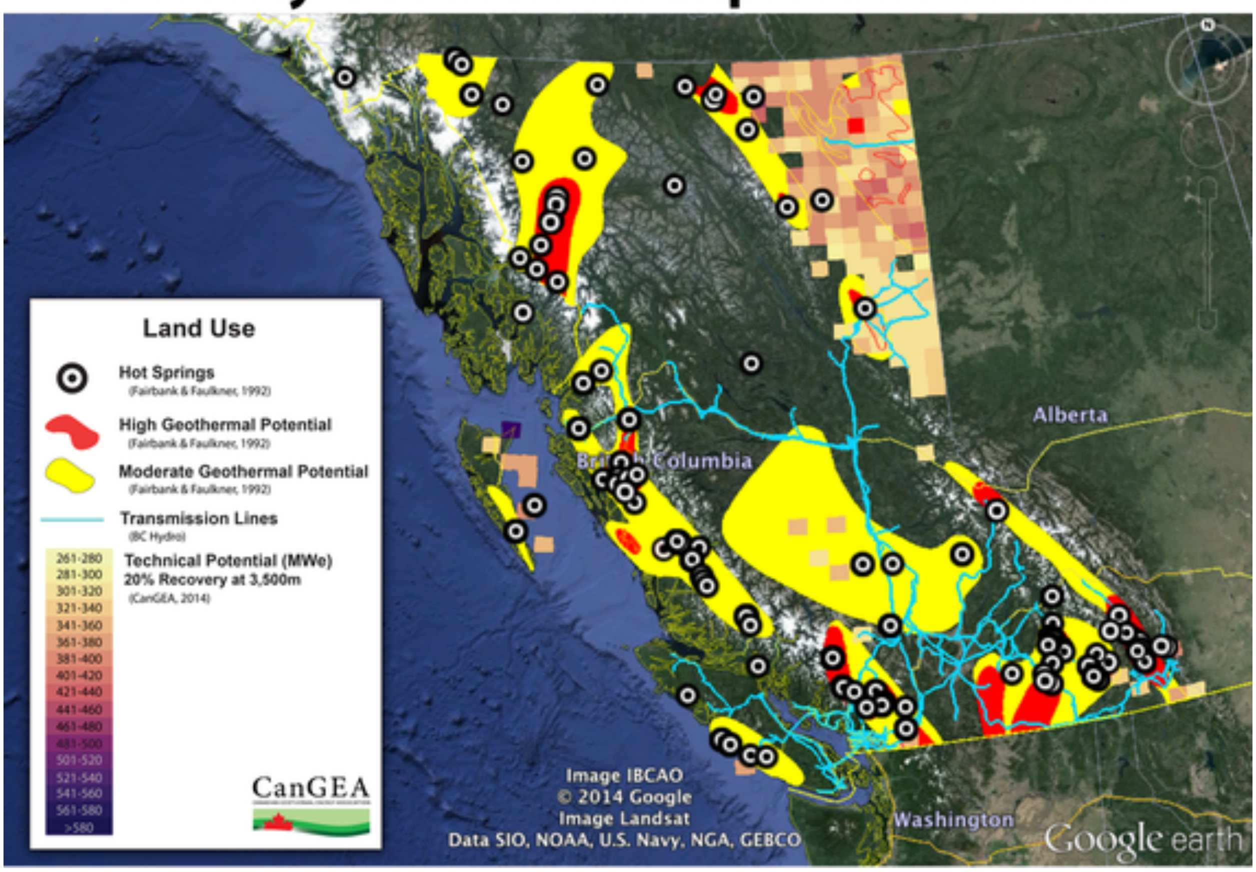
# Comments on Alternative Portfolios

**October 18, 2017**

## Priority Geothermal Exploration Areas



## Canadian Geothermal Energy Association (CanGEA)

CanGEA is the collective voice of Canada's geothermal energy industry, and provides a forum to promote geothermal energy development in Canada and abroad. As a non-profit industry association, CanGEA represents the interests of its member companies, with the primary goal of unlocking the country's tremendous geothermal energy potential.

We are asking the Commission to approve our application for intervener status, so that we can fully participate in the inquiry proceedings and make application for a cost award in accordance with the Commission's Rules of Practice and Procedure.

CanGEA meets the criteria for standing to participate as an intervener in this proceeding. CanGEA's interests, and the interests of its members, who are existing or potential developers of geothermal electricity in BC, will be directly affected by the Commission's findings on Section 3(b)(iv) of the Inquiry's Terms of Reference, pertaining to what, if any, other portfolio of commercially feasible generating projects could provide similar benefits to ratepayers at similar or lower unit energy cost as the Site C Project. CanGEA qualifies both as an interested party (as per Section 3(d) of the Inquiry's Terms of Reference) and a source of expert advice (as per Section 3(f) of the Inquiry's Terms of Reference) that the Commission must and may consult, respectively. CanGEA therefore respectfully makes this submission and requests the Commission grant CanGEA intervener status and the ability to apply for a cost award.

Our members are the visible embodiment of our commitment to the development and production of clean, renewable and sustainable geothermal energy. It is through our collective desire and dedication that we continue to achieve progress in this industry towards making geothermal energy a reality in Canada.

It should be noted that in addition to CanGEA member projects there are two other development projects in British Columbia by companies who are not CanGEA members but also are trying to develop geothermal resources. While CanGEA acts in the interests of its members, and will mention its member projects in this submission by way of example, there are some attempts at development ongoing outside of what is being undertaken by CanGEA members.

## Table of Contents

## Introduction

In Section 6.4.3 of BC Hydro's submission, they make the following statement:

> "In our response to BCUC IR 2.61, we found that expecting material amounts of geothermal electricity generation in BC by 2025 is unrealistic."

In response, on October 12, 2017, in Commission Letter 22-1, the Panel prepared an alternative portfolio of renewable sources that left out geothermal. While understandable that the Panel might leave out geothermal given the misinformation being propagated by Geoscience BC's report, "An Assessment of the Economic Viability of Geothermal Resources in British Columbia", regarding geothermal electricity's economic viability, nevertheless geothermal should be included in an alternative portfolio to Site C. In this submission, CanGEA will make the case to put geothermal back in.

But why hasn't geothermal been included in BC Hydro's development portfolios up to this point? Why did it take the BCUC to propose an alternative portfolio that, while itself not including geothermal, at least noted the possibility of including it?

The Panel has asked why BC Hydro removed geothermal from its development portfolio, and CanGEA has an answer. BC Hydro removed geothermal because BC Hydro based that decision on the flawed results of the 2015 Geoscience BC report "An Assessment of the Economic Viability of Geothermal Resources in British Columbia".

CanGEA contends that while some good came out of the Geoscience BC report including greater awareness of geothermal in BC and the fulsome appendices on select geothermal sites, that report cannot be the final word on BC geothermal costs. Nor even the official result by which BC Hydro should select portfolio components. CanGEA contends this because the report was created through a demonstrably flawed process.

On October 14, the Panel heard testimony from Randy Reimann (BC Hydro), who remarked that Geoscience BC, and its subcontractors Kerr Wood Leidal and GeothermEx, have an advisory board of geotechnical experts to advise them and that they did their "best assessment". However it seems clear that BC Hydro was provided with bad advice from Geoscience BC and its associates. This is born out by CanGEA's wealth of data and expertise from such sources as the National Renewable Energy Laboratory (NREL), the US Geological Survey, and actual US developers of geothermal, all of whom are simply more credible and experienced than Geoscience BC. Sadly, BC Hydro put their trust in the wrong people, and ended up with bad data and commensurately bad conclusions.

The 2015 Geoscience BC report's primary challenge is that while there were, and remain, 3 active BC geothermal developers and several natural gas developers who have drilled into geothermal resources, all regulated by BC Energy, Mines and Petroleum Resources, they were not provided a meaningful role in the technical advisory committee. Further, CanGEA produced a comprehensive critique of the Geoscience BC report, which went unheeded. Regarding scope, by largely ignoring the hot sedimentary aquifers of North-East BC the report does not include potentially thousands of geothermal megawatts. This is an issue CanGEA has spoken on extensively in publicly available reports.

As for peer review before the report was published, evidence based decision making in any other technical field would require subject matter experts to review and be able to offer comment on the results of the report, specifically the levelized cost of electricity (LCOE) and resource availability estimates. In this case, subject matter experts on geothermal development in BC should have included the developers of the BC geothermal sites investigated. For an example of proper peer review, the CanGEA BC favourability map project had the MW estimates confirmed by the International Geothermal Association (IGA) Reserves and Resources Committee Chair, Dr. Graeme Beardsmore, as well as BC developers. The conclusion of the report that geothermal is scarce, risky, and expensive is in direct opposition to the everyday reality in BC where 3 different project developers have concluded that the resource can be profitably developed throughout the province. CanGEA and our members hold that the issues holding back BC geothermal are policy and misinformation, not technical viability or cost.

The expertise and practices of the Geoscience BC's geothermal technical committee has grown since its inception, and CanGEA looks forward to continuing to work with that group. The inclusion of developers to determine cost estimates is a best practice used around the world by such leaders as the United States Department of Energy Geothermal Technology Office. The absence of developer voices in the 2015 Economic viability report is a void that cannot be ignored by BC Hydro. If "An Assessment of the Economic Viability of Geothermal Resources in British Columbia" was re-commissioned today and was re-created with world leading best practices for the assessment and quantification of geothermal resources, as CanGEA presented to the Commission on October 14, 2017, we believe a remarkably more positive result would be found. CanGEA's data is produced according to the guidelines of the World Bank Energy Sector Management Assistance Program (ESMAP), an international quality standard. A report under this standard would show that BC geothermal is a plentiful and cost competitive energy solution for the province.

Geoscience BC's own practices have evolved past those used to develop "An Assessment of the Economic Viability of Geothermal Resources in British Columbia" so BC Hydro should not continue to reference that report to make decisions. **Tragically, this has not been the case despite explicit assurances in 2015 from BC Hydro to CanGEA that the report would not be used for development plans, as BC Hydro recognized the systematic problems of the report.**

So why should geothermal be included in the Commission's new alternative portfolio?

The twin priorities of the Commission's alternative portfolio are the cost-effectiveness of the energy, and capacity of the generator technology. Geothermal electricity provides both.

CanGEA
CANADIAN GEOTHERMAL ENERGY ASSOCIATION

CanGEA strongly encourages the 200 MW of geothermal electricity to be brought online immediately, and more when load develops. Any build of geothermal electricity provides BC Hydro and PowerEx with the opportunity to partially refrain from generating from BC Hydro facilities, and instead use those reserved MW to sell into the spot market to PowerEx's economic advantage at a time of their choosing. Geothermal electricity can support the grid, displacing BC Hydro MW as the base load generating technology and allowing BC Hydro's own facilities to be used as a complementary battery.

CanGEA refers the Commission to page 24 of our submission of October 10, where we describe how realistic it would be to bring geothermal electricity online not just by 2025, but by 2020.

In our view, it would be reasonable to suggest that, from 3 of the existing identified locations (CanGEA members' projects at Canoe Reach and Lakelse Lake, and Pemberton), ~40 MWe of geothermal capacity could be brought on stream, each year, starting in 2020 and ending in 2024. This would suggest that by close of 2024, ~200 MW of geothermal capacity could be online and actively generating electricity. This is consistent, or even conservative, when compared to recent developments in Turkey, a recent entrant into the geothermal space.

Turkey is a large country, similar in size to BC, which also possesses varied geothermal resources just as BC is expected to. Additionally, most geothermal plants in Turkey are located in one quadrant of the country and therefore represent a similar regional concentration to both the United States and Canada in terms of geothermal potential.

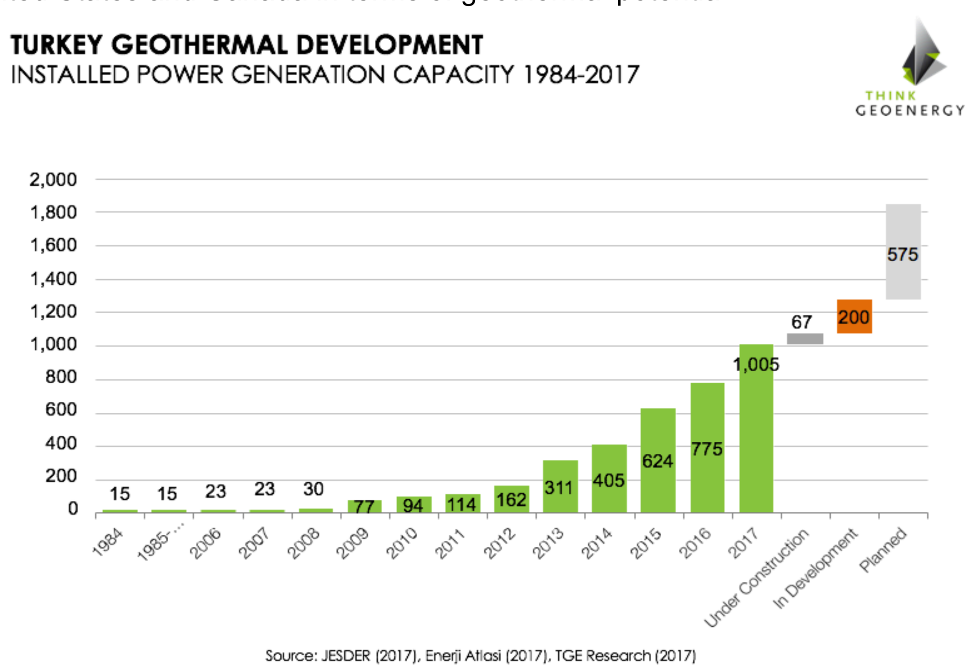



*Chart 1: Turkey Geothermal Development*

Note how Chart 1 (above) illustrates a skyrocketing geothermal capacity in Turkey (once government and regulators got on board). Policies and regulations friendly to geothermal development, plus found resources, equals a thriving geothermal industry.

On October 14, 2017 CanGEA's Chair mentioned the speed at which Turkey and the United States were developing their geothermal energy capacity, however did not present any US-specific supporting evidence.[1]

Chart 2, below, demonstrates the geothermal energy capacity additions between 2006 and 2016 in the US. As Chart 1 reveals, a total of 798 MW have been added to the US capacity base since 2006.

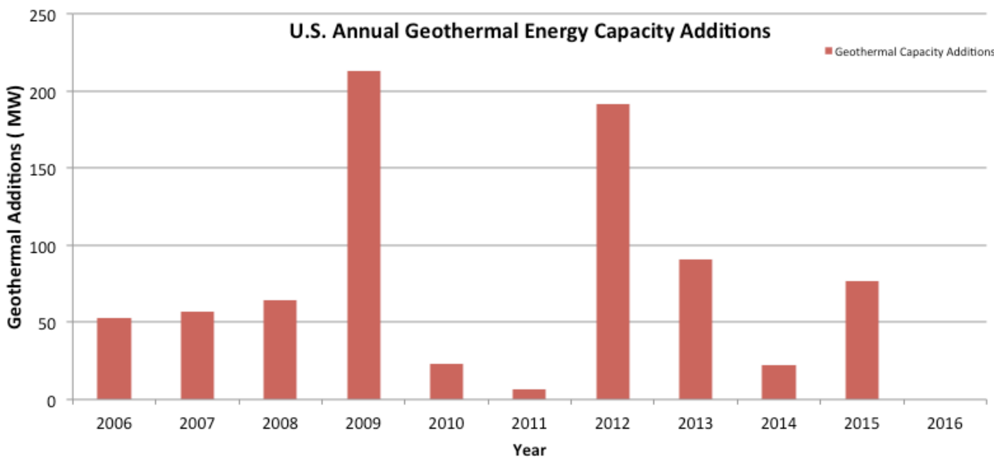



*Chart 2: U.S. Annual Geothermal Energy Capacity Additions from 2006-2016*[2]

In Appendix A (page 10 of 13) of BC Hydro's submission of October 11, they describe the Valemount and Pemberton (Pebble Creek) sites as having applied to BC Hydro's Standing Offer Program, but had not yet been accepted. They go on to state neither site has proven the viability of the underlying resource through confirmation drilling, and to date there has not been any confirmed viable geothermal reservoir in BC.

When considering these sites it is important to note that the Canoe Reach site at Valemount is waiting on a permit expansion from the Ministry of Energy, Mines, and Petroleum Resources, necessary in order to efficiently develop the resources found. The developer of the Canoe Reach site has been waiting for the permit expansion to be issued since applying in May 2016.

[1] British Columbia Utilities Commission, *Technical Input Proceedings – October 14, 2017* (transcript), Presenter: Alison Thompson, Chair of CanGEA, pg. 1501 line 5-13.
[2] National Renewable Energy Laboratory (2017).

The Canoe Reach developer met all requirements for a permit expansion and was issued a letter to that effect by the Ministry of Energy, Mines, and Petroleum Resources on February 27, 2017. However, a new regulation had to be developed allowing the Ministry to proceed with the issuing of the permit. It was not until September 2017 that the regulation was finally developed. On October 13, 2017, the Ministry of Energy, Mines, and Petroleum Resources advised the developer that the Order in Council necessary for issuing the permit was now with Cabinet operations, meaning that after much delay, issuing of the permit may finally be imminent.

The previous government dragged its feet in permitting geothermal development in British Columbia, significantly setting back the industry development. However, under the new provincial government, encouragingly the regulatory process in BC in 2017 has seen much improvement, moving toward a single-window environment with the BC Oil & Gas Commission (OGC) to assist with 'fast tracking' of geothermal land access and drilling permits.

Without the support of government, neither geothermal developers nor BC Hydro can efficiently develop BC's geothermal potential. As the Canoe Reach site demonstrates, lack of regulatory support under the old government delays the project and prevents exploration that would prove the reservoir's viability. We believe this to be remedied (or significantly improved) with the new provincial government.

Furthermore, while BC Hydro points out that both applications were for less than 15 MW this is because BC Hydro's Standing Offer Program has a limitation cap of 15 MW. If more MW are desired, the Canoe Reach application can be amended, up to 58 MW (the projected P90 site potential); our data on the production capacity of the Valemount site is readily available in our submissions of August 30 and October 10. Staying within the imposed limitation of the Standing Offer Program should not be held against the viability of geothermal resources in British Columbia, by suggesting they lack materiality.

## Capital Expenditures and Operations & Maintenance Costs

The cost of geothermal electricity speaks to its suitability for inclusion in an alternative portfolio.

Observe Chart 2 on the following page of Levelized Cost of Electricity, used in the testimony before the Panel by CanGEA's Chair on October 14.

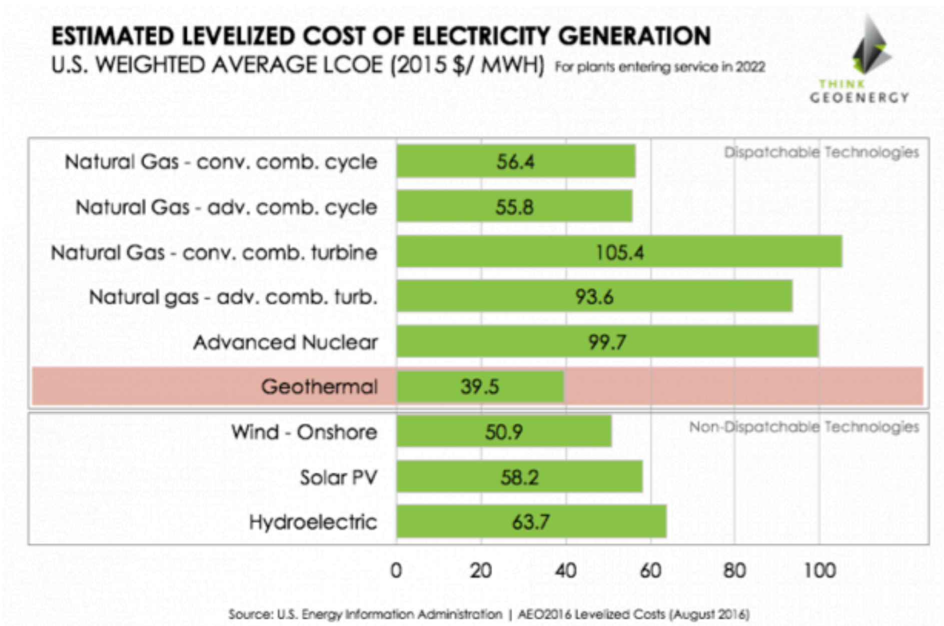



*Chart 3: Estimated Levelized Cost of Electricity Generation, U.S. Energy Information*

Capital expenditure estimates for geothermal projects in BC are in line with real costs of similar projects in countries like the United States who have developed geothermal generation. As a result, budgets for geothermal projects included in an alternative portfolio to Site C may be easily calculated, economic models run, and geothermal's cost-effectiveness determined.

Independent assessment of the Canoe Reach site by Dewhurst Group LLC, using standard heat-in-place stochastic methods, reveals the Canoe Reach reservoir may generate (at P90, or 90% probability to be the minimum electricity generated) 58 MWe of continual (gross) electricity (flash or binary plant) over a 30-year span. The P50 figure is 139 MWe over a similar timespan. The P10 figure is 295 MWe over a similar timespan. Guidelines of the World Bank Energy Sector Management Assistance Program (ESMAP) suggest that the MW produced at P90 are likely to have an average development cost of USD$240 Million.

Lakelse Lake, located near the town of Terrace, BC, is another example with significant potential for electricity generation. Independent assessment of the reservoir by Dewhurst Group LLC, again using standard heat-in-place stochastic methods, expects the reservoir to be able to achieve a P90 figure of 23 MWe of continual (gross) electricity over a 30-year span. The P50 figure is 54 MWe. The P10 figure is 113 MWe. The project could produce P90 MW at an approximate average development cost according to ESMAP guidelines, of USD$96 Million.

The following summarizes the findings of these P90 assessments:

**Canoe Reach, at a cost of CAD$300 Million[3] for 58 MW, has an installed capital of approximately CAD$5.1MM/MW for a 95% capacity factor.**

**Lakelse Lake, at a cost of CAD$120 Million[4] for 23 MW, has an installed capital of approximately CAD$5.2MM/MW for a 95% capacity factor.**

For illustrative purposes that mirror an expected Electricity Purchase Agreement timeframe, CanGEA has chosen a 30-year notional project life for each of the Site C and the Canoe Reach geothermal projects. Next, the gross MWh delivered is calculated, taking into consideration the capacity factors of each project. This leads to 153,212,400 MWh for Site C, 14,480,280 MWh for Canoe Reach, and 5,726,448 MWh for Lakelse Lake.

These values are then divided by total capital cost to calculate the ratio of capital cost per MWh produced.

**At a capital cost of CAD$300 Million, Canoe Reach has an approximate capital cost to generation ratio of CAD$20.7/MWh.**

**At a capital cost of CAD$120 Million, Lakelse Lake has an approximate capital cost to generation ratio of CAD$20.9/MWh.**

It is important to note that these geothermal projects share with Site C the quality of becoming more economical over time. By extending the project life to 50 years rather than 30 (a reasonable prospect given that both the United States and New Zealand possess geothermal facilities that have been in continuous operation for over 50 years, and Iceland has a 48-year-old facility) the capital cost to generation ratio drops even lower.

Observe the following information prepared by the United States government.

[3] Based on 1.25 USD-CAD conversion rate, current as of August 28, 2017. CAD$300 = USD$240
[4] Based on 1.25 USD-CAD conversion rate, current as of August 28, 2017. CAD$120 = USD$96

| Geothermal Resource and Cost Characteristics | | | | | |
|---|---|---|---|---|---|
| | | Temp (°C) | | | |
| Hydrothermal | | ≥200°C | 150-200°C | 135-150°C | <135°C |
| | Number of Identified Sites | 21 | 23 | 17 | 59 |
| | Total Capacity (MW) | 22,718 | 5,560 | 1,173 | 9,697 |
| | Average OCC (millions $/MW) | 4.05 | 6.8 | 8.61 | 15.37 |
| | Min. OCC (millions $/MW) | 3 | 3.91 | 6.79 | 10.6 |
| | Max. OCC (millions $/MW) | 5.91 | 15.31 | 11.89 | 20.6 |
| | Example Plant OCC (millions $/MW) | 4.57 | 5.47 | | |
| Base Year Estimates from: https://atb.nrel.gov/electricity/2017/index.html?t=gt | | | | | |

*Table 1: U.S. Geothermal Resources and Cost Characteristics*

Table 1[5] (above) shows the Overall Capital Cost of various geothermal project types. This is in line with our previous estimates for Canadian projects' capital expenditures as seen in our cost breakdowns for Canoe Reach and Lakelse Lake in this and earlier submissions.

It is interesting to note the large total resource capacity expected in the United States.

Operations and maintenance (O&M) costs represent average annual fixed expenditures (and depend on rated capacity) required to operate and maintain a geothermal plant over its technical lifetime of 30 years (plant and reservoir).

The following figure shows the Base Year estimate and future year projections for fixed O&M (FOM) costs. Three cost reduction scenarios are represented. The estimate for a given year represents annual average FOM costs expected over the technical lifetime of a new plant that reaches commercial operation in that year.

Observe Chart 4 below.[6]

---

[5] National Renewable Energy Laboratory, *Annual Technology Baseline – Geothermal, O&M Costs*, *https://atb.nrel.gov*, accessed October 16, 2017, https://atb.nrel.gov/electricity/2017/index.html?t=gt

[6] National Renewable Energy Laboratory, *Annual Technology Baseline – Geothermal, O&M Costs*, *https://atb.nrel.gov*, accessed October 16, 2017, https://atb.nrel.gov/electricity/2017/index.html?t=gt

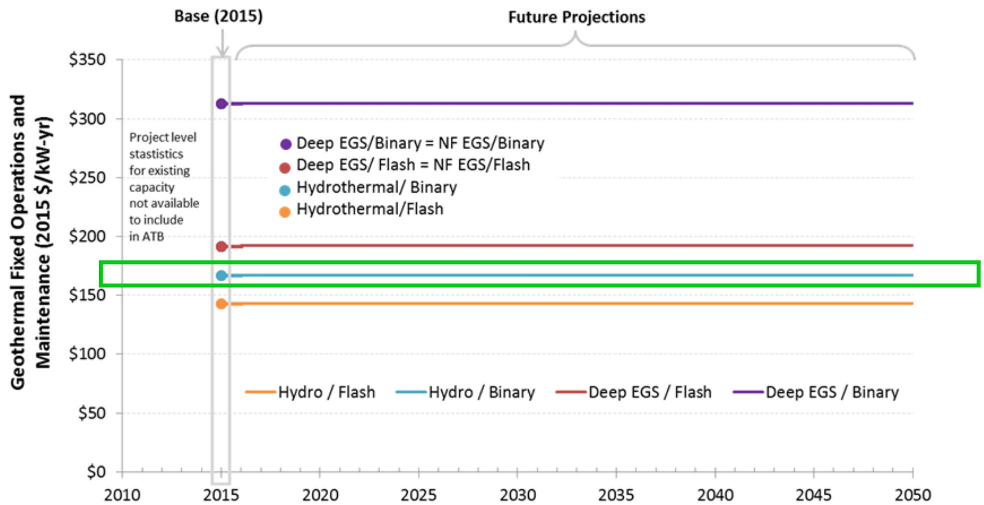



*Chart 4: Geothermal Fixed Operations and Maintenance (2015$/kWh-yr, National Renewable Energy Laboratory (2017)*

Binary hydrothermal geothermal electricity plants, shown in the green rectangle in the above chart, have an approximate operating and maintenance cost of USD$170/kW-year which is equivalent to USD$19.40/MWh.

CanGEA encourages the Commission staff to run their own model using these CapEx and OpEx numbers and those provided to the Commission by CanGEA in our previous submissions. Geothermal projects at Canoe Reach and Lakelse Lake and Pemberton are capable of putting 40 MW of base load electricity onto the grid each year starting in 2020, with 200 MW online by 2025, i.e., the portfolio would add 40 MW of base load electricity onto the grid per year, not 40 MW per site.

If additional MW are desired, either additional geothermal sites can be developed, or development of the initial 3 sites' P10 resources can be targeted.

## Grid Firming, Reliability, Capacity, and Shaping

When first developed, especially in the BC context, intermittent energy sources were primarily envisioned to be "backed-up" by more reliable electricity sources such as large hydro.[7] However, many experts expect climate change to adversely impact water availability in Alberta and British Columbia in the future, and "climate-induced droughts are projected to reduce hydroelectric generation".[8] Within this context, geothermal energy's base load capacity is of special note.

Geothermal electricity plants often exceed hydroelectric projects in terms of their availability, especially when taking into consideration the challenges posed by climates with frigid winters, and the aforementioned expectations with regards to climate change. As a case in point, new geothermal electricity plants routinely achieve >95% in terms of availability.[9] Demonstrative of such reliability are the following projects operated by U.S. Geothermal. The company's Neal Hot Springs project in Oregon, reported a 99.1% capacity factor, a 96.1% capacity at its project at San Emidio in Nevada, and a 99.7% capacity factor for its project at Raft River in Idaho.[10] *Figure 1* demonstrates a comparison of the capacity factors of various energy sources, which was taken from a report released by the Canadian Geological Survey. [11]

[7] Hugh Scorah, Amy Sopinka, G. Cornelis van Kooten, "The economics of storage, transmission and drought: integrating variable wind power into spatially separated electricity grids" Energy Economics 34 (2012): 536.

[8] Scorah et al., 536-537.

[9] Activated Logic, "Geothermal Energy in Australia" Australian Geothermal Energy Association (Adelaide, Australia: December, 2009): 9.

[10] Saf Dhillon, "U.S. Geothermal Provides Project Update" Market Watch, <http://www.marketwatch.com/story/us-geothermal-provides-project-update-2014-10-23-8173650>, (October 23, 2014, Accessed: October 24, 2014).

[11] S. Grasby, D. Allen, S. Bell, Z. Chen, G. Ferguson, A. Jessop, . . . R. Therrien, "Geothermal Energy Resource Potential of Canada" Natural Resources Canada, (2012): 1.

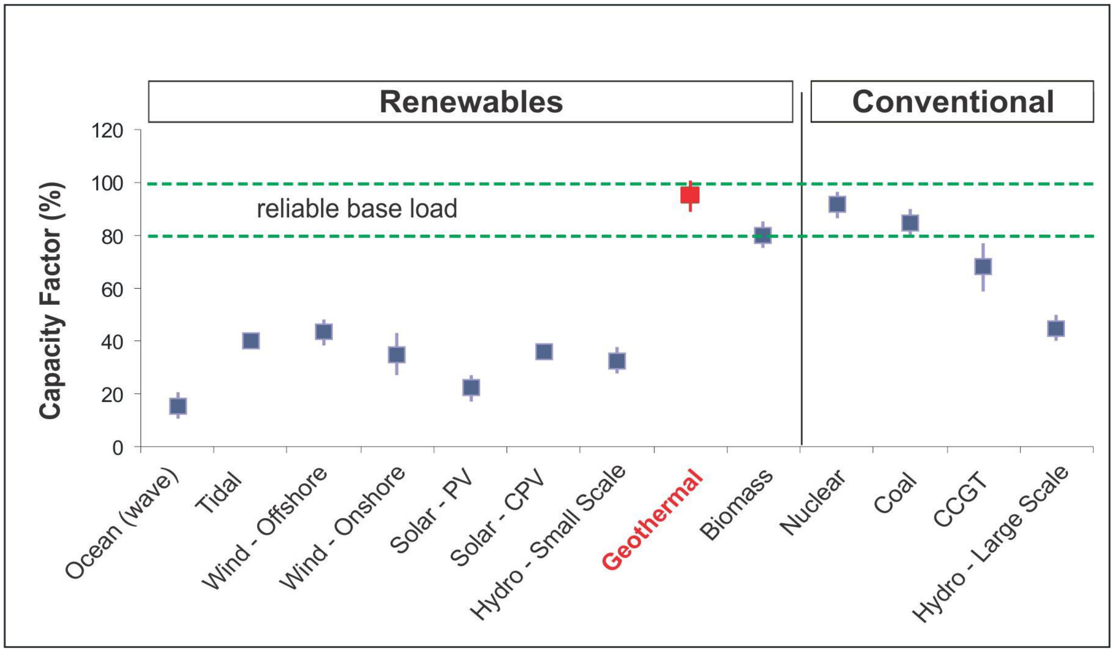



*Figure 1: Comparison of the Generation Capacity of Various Energy Sources*

Such high capacity factors are testament to the attractiveness of geothermal energy as a base load energy source, however it does not consider some of the other traits that make geothermal energy such a valuable contributor to electrical grids. For example, many modern geothermal electricity plants are able to ramp production up and down multiple times per day, from a minimum of 10% of nominal electricity, up to 100% of nominal electricity output.[12] This ability to be ramped up and down makes geothermal energy a dispatchable energy source, as it possesses the ability to be controlled by a system operator, and “to be turned on and off” or ramped up and down.[13]

Decisions with regards to ramping up and down are generally based upon the economic attractiveness both to supply electricity and to supply network reliability services. It is worthy to quote at length, the thought process generally involved in such decisions. “Supplies from conventional dispatchable generators are typically increased or decreased by the system operator to meet demand by dispatching the generators to supply electricity with the lowest marginal generation cost or bid offer price first and then moving up the ‘dispatch curve,’ calling on generators with higher marginal costs or bid prices until the demand for electricity is satisfied in real time.”[14]

---

[12] Matek, October 2013, 12.
[13] Paul L. Joskow, “Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies” American Economic Review: Papers & Proceedings 100, no. 3, (2011): 238.
[14] Joskow, 238.

To keep things simple, and ignoring market electricity considerations, conventional base load generators are typically dispatched when the wholesale market price for electricity exceeds their short-run marginal cost of generating electricity. In considering this, intermittent energy sources cannot react to such market forces in quite the same way, as the rate at which their turbines rotate is dependent upon independent variables such as wind speed.

Intermittent energy sources are typically understood to be attachable, at will, to the transmission grid. However, as these electricity sources are not dispatchable, only at the current relative low levels of grid penetration is such a situation manageable.[15] This is largely a result of the fact that present transmission lines were not designed to deliver large amounts of fluctuating levels of electricity. When this is the case, transmission operators must "condition" the electricity.[16] "This requires intense attention to the moment-by-moment condition of the electricity in the lines; it is expensive, and is awkward compared to handling dispatchable electricity."[17] In contrast, grid operators understand dispatchable electricity, and electric utilities know how to move and control it. Moreover, it is the electricity source that grid systems have historically been designed for.[18]

It is important to be clear that these attributes do not hold that there is no place on the grid for intermittent energy sources. **Rather, geothermal energy's base load and dispatchable qualities actually strengthen the grid in a complementary way, allowing for more intermittent energy sources, e.g., wind, solar and run of river hydro, to be used.** Moreover, recent research models have demonstrated the ability of hybridization between solar systems and binary geothermal systems to enhance the production and reliability of both.[19]

BC Hydro, in their submission of September 22, 2017, cited transmission and road costs as a concern with the portfolio assembled by Deloitte LLP based on data from Geoscience BC. We, too, are concerned with Geoscience BC's data, and here is another example why.

CanGEA cannot speak directly to the costs of non-member projects, but in the case of the Canoe Reach and Lakelse Lake projects, both transmission and road costs are negligible due to both projects' locations. Both Canoe Reach and Lakelse Lake are located on pre-existing transmission lines and road systems. None or very little additional road or transmission line construction is necessary. Therefore the road and transmission costs for these projects are very low.

The proposed location of the Canoe Reach facility has power line and road access already, and would not be subject to multimillion-dollar access requirements as suggested by the Geoscience

[15] Bernard Lee and David Gushee, "Renewable Power: Not Yet Ready for Prime Time" Chemical Engineering Progress 105, no. 4, (April, 2009): 22.
[16] Lee and Gushee, 22.
[17] Ibid.
[18] Ibid., 23.
[19] Hadi Ghasemi, Elysia Sheu, Alessio Tizzanini, Marco Paci and Alexander Mitsos, "Hybrid solar-geothermal power generation: Optimal retrofitting" Applied Energy 131, (2014): 158.

BC report. A CanGEA member is currently working with local contractors to finalize exact costs to interconnect, but estimate it to be <$1MM. In the photograph below, the star represents the future facility location. Similarly favourable road and transmission infrastructure exists at Lakelse Lake as well.

The location for the power facility at the Lakelse property is located within 1 km of major transmission infrastructure and within 3 km of the Skeena Substation (TER 25F562). There are local distribution power lines and road access to the proposed power plant location.

BC Hydro provided, in a Basic Distribution Study, the following comment:

> "From the POI [Point of Interconnection] to the closest BC Hydro station, there is approximately zero km of single phase line that would require upgrading to 3-phase for this interconnection. There is also the likelihood that 0.1 km of 3-phase line will need to be reconductored to accommodate this interconnection."

A thorough breakdown of the capital costs for Canoe Reach and Lakelse Lake can be found in CanGEA's submission of August 30, 2017.

In addition to saving the cost of transmission and road building necessary to serve the projects themselves, geothermal projects also can improve the existing transmission network. Moreover, they can help customers by improving local electricity service and reducing BC Hydro's costs in these areas. For instance, purchasing electricity from a base load project located at the end of a long radial transmission line, will improve the level of electricity service and reliability to local customers.

Look once again at the Canoe Reach project. As a result of its location at the end of a 300 km long 138 kV radial transmission line, the Valemount region is known for frequent electricity outages. Placing base load capacity near Valemount will not only secure electrical service in the region, it will also negate the need for expensive upgrades to or expansion of the existing transmission line. This will help reduce some pressure for BC Hydro to increase electricity rates. It will also help to avoid regional economic damages caused by brownouts and electrical instability. The inclusion of a base load project would also allow Valemount to grow its aggregate demand from incoming business projects such as the approved Valemount Glacial Destinations Resort.

Similarly, the Lakelse Lake geothermal project near Terrace is not only poised to serve developing industrial loads, it also would reduce or eliminate line losses from Prince George through Terrace to Bob Quinn Lake**. Additional geothermal resources in the province are located in 'end-of-line' scenarios as well.**

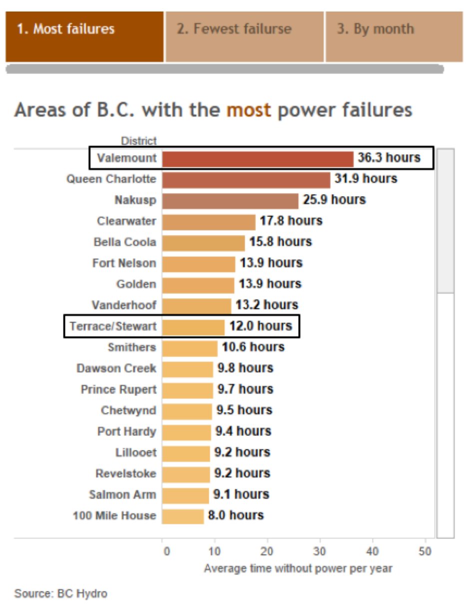



*Chart 5: Areas of B.C. with the most power failures*

Observe Chart 5 on the previous page, where Valemount is listed as the single most likely area to suffer from electricity failures in the Province. Terrace (the location of the Lakelse Lake project) is not far behind at number 9. Both these areas would immediately benefit from base load projects.

As a third example, building geothermal projects near Fort Nelson would help electrify new industrial load. This could likely save BC Hydro ratepayers hundreds of millions of dollars by avoiding or delaying the need to build a new North-East Transmission Line, the feasibility of which is still being studied by BC Hydro but the cost of which is estimated at $1 billion.

**Building around the province to support the transmission system also creates choice for the Government of BC, BC Hydro, and its industry partners, as to how to distribute the jobs, electricity, and heat from geothermal, wherever they are most needed in BC.**

In consideration of all these arguments, it is worthy to note that state governments in the U.S. have moved towards recognizing the value of such characteristics. For instance, in September 2014 the California Governor signed Assembly Bill 2363 into law.[20] This law requires the California Public Utilities Commission to create “adders” or “integration costs” for the evaluation of energy technologies, and that these must be used in the awarding of long-term wholesale electricity contracts. This change addresses the concerns raised above, and also places the appropriate costs to solar, wind electricity and run of river hydro. The result of this is to allow for base load renewables such as biomass and geothermal energy to compete for Power Purchasing Agreements (PPAs) based on a more accurate comparison of the full cost for electricity.

In their technical presentation, BC Hydro extolled the benefits of hydroelectric electricity as suitable for the “cold, dark winters”. It is important to note that this is also a benefit of geothermal.

**Moreover, in colder climates, like Canada, there is the ability to generate more electricity output in the winter months. This occurs as the change in temperature harnessed by the power cycle increases when the ambient temperature falls and the reservoir temperature remains the same.**

**This “winter sprinting” ability of geothermal electricity can be achieved with no additional capital investment. This matches exceptionally well with the “winter peaking” electrical grid that exists within BC.**

[20] California Legislative Counsel, “Assembly Bill No. 2363” California State Assembly, (Sacramento: California: September 26, 2014).

## Geothermal Resource Estimates

Zero MW of geothermal electricity are currently being produced in Canada. This is despite the fact that our closest neighbour the United States, using geology remarkably similar to particularly Western Canada, is the number 1 producer of geothermal electricity in the world. CanGEA believes that British Columbia has immense potential for geothermal development.

| **Technical Potential for Geothermal in British Columbia from Sediments Only - NTS Grid Version**<br>*where values represent Potential Power from Indicated Resources only | | |
|---|---|---|
| **Recovery** | **Depth** | **Generation Potential**<br>Indicated Resources |
| 5% | 1,500m: | 133 MW |
| | 2,500m: | 5,723 MW |
| | 3,500m: | 2,613 MW |
| | **Total** | 8,469 MW |
| Installed Generation Capacity (all sources): | | **0 MW** |

*According to the Canadian Geothermal Reporting Code

*Figure 2: Technical Potential for Geothermal in British Columbia from Sediments Only (CanGEA)*

As Figure 2[21] demonstrates, with the lowest studied recovery factor of 5%, and a relatively shallow depth of 2,500m, there is 5,700 MW of geothermal electricity potential suitable for Hot Sedimentary Aquifer (HSA) production in BC. This is a conservative estimate given the preceding factors. Recovering even more than 5% from the resource would cause the generation potential to skyrocket.

These figures were produced in accordance with the Geothermal Code for Public Reporting (Reporting Code). Further, they utilized an adapted Protocol for Estimating and Mapping Enhanced Geothermal Systems (EGS) Potential. This is commonly referred to as the Global Protocol. The methodology was adapted by the author of the original Global Protocol, for use with HSA. The EGS Global Protocol easily lends itself for application to HSA systems, as both are conductive temperature regimes.

[21] *CanGEA, "Geothermal Energy: The Renewable and Cost Effective Alternative to Site C*, 2014 https://www.cangea.ca/reports--resource-material.html

In assembling this data, CanGEA used 75,160 data points in the project, which were filtered down to 18,019 data points. This data is publicly available as a result of oil and gas activity. The extent of the data underlying this MW estimate cannot be overemphasized.

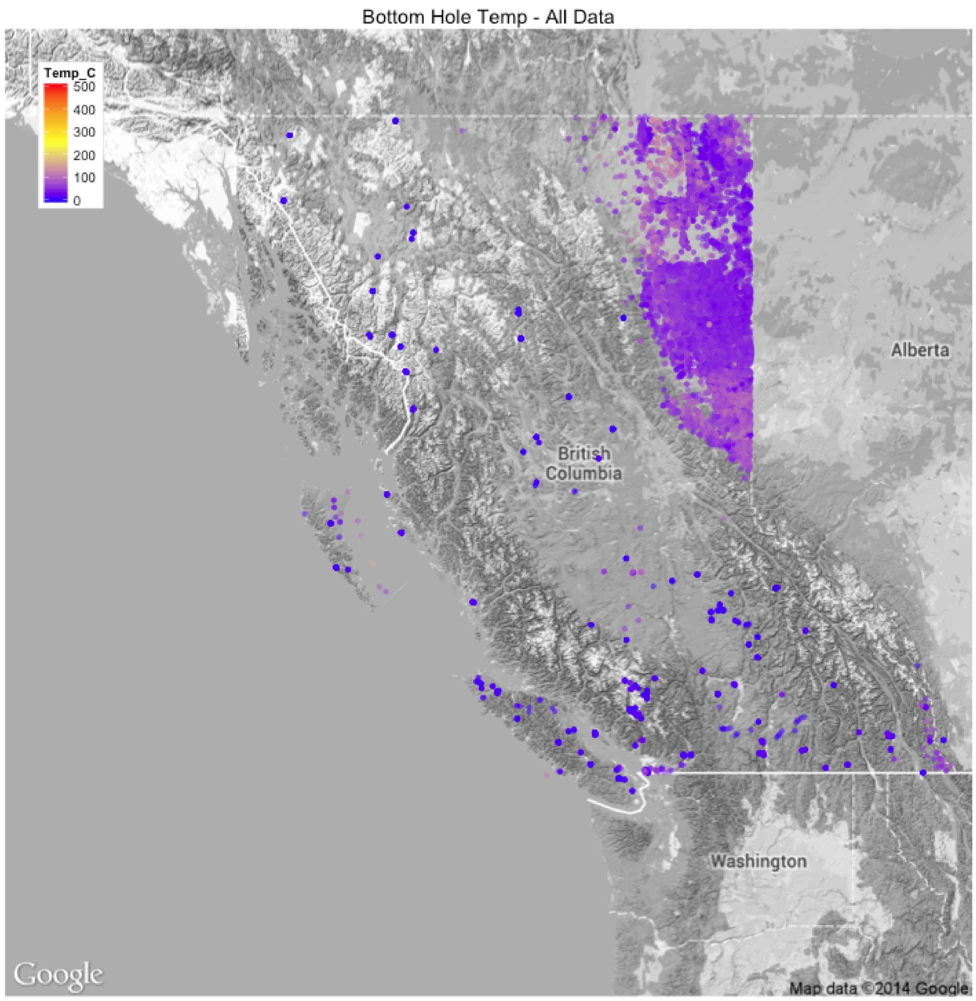



*Figure 3: British Columbia Temperature Data Used in the Report (CanGEA)*

The above Figure 3[22] shows the location of all the data points used to assemble the 5,700 MW estimate. As can be seen, data was taken from all across the province, making it reasonable to suggest that sites with geothermal potential are widely distributed. This creates choice for the Government of BC, BC Hydro, and its industry partners, as to how to distribute the jobs and

---

[22] *CanGEA, "Geothermal Energy: The Renewable and Cost Effective Alternative to Site C*, 2014 https://www.cangea.ca/reports--resource-material.html

electricity transmission firming support from geothermal projects, wherever they are most needed in BC.

The same methodology was used in conducting similar studies of Alberta and Yukon, producing similar favourability maps with government support and the cooperation of the Alberta Geological Survey (AGS) and Yukon Geological Survey (YGS). Both the AGS and YGS accepted CanGEA's findings, and YGS has even planned drilling campaigns in 2018. Yet Geoscience BC rejected CanGEA's findings and favourability maps, to CanGEA's bafflement.

Data from the United States supports our estimate, as geologically similar territory south of the border has already been developed to produce considerable amounts of geothermal electricity.

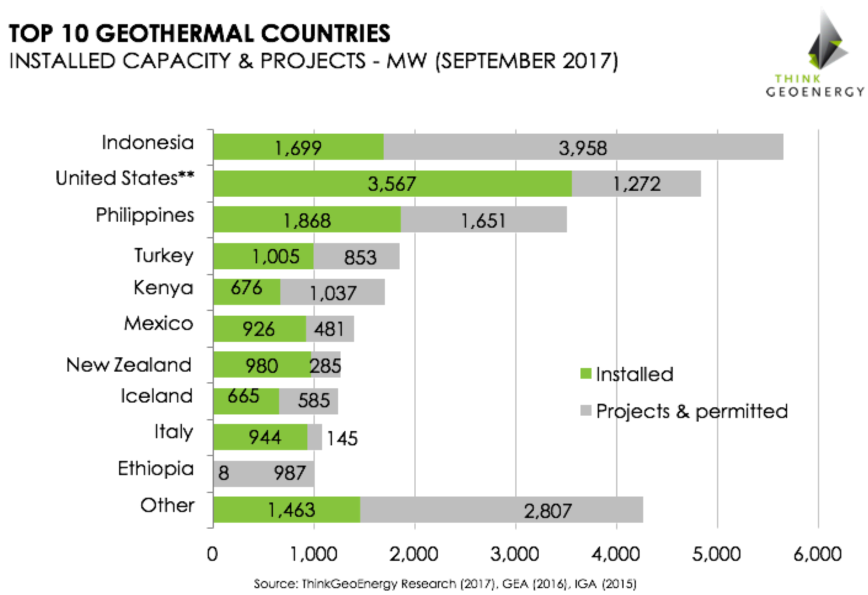



*Chart 6: Top 10 Geothermal Countries, ThinkGeoEnergy (2017)*

Chart 6 above lists the installed geothermal capacity of several prominent geothermal-producing nations. The United States has installed 3,567 MW of geothermal capacity, with 1,272 MW more currently in development.

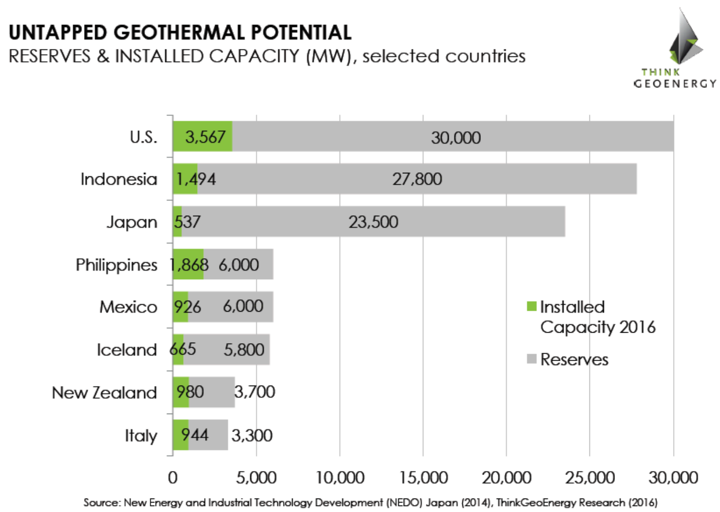



*Chart 7: Untapped Geothermal Potential, NEITD (2014)*

The United States further has approximately 30,000 MW as yet undeveloped (See Chart 7 above). Scientists with the US Geological Survey (USGS) recently completed an assessment of geothermal resources in the United States. The assessment indicates that the electric power generation potential from identified geothermal systems is 9,057 MWe, distributed over 13 states. The mean estimated electricity production potential from undiscovered geothermal resources is estimated by this survey at 30,033 MWe. Additionally, another estimated 517,800 MWe could be generated through implementation of technology for creating geothermal reservoirs in regions characterized by high temperature, but low permeability, rock formations.[23]

**Estimates for US production capacity don't stop at the border. With the United States poised to harness this much geothermal potential, in geology similar to British Columbia, it is clear that geothermal must be included in any alternative portfolio of energy sources intended to substitute for the Site C project. There is simply too much geothermal potential in BC to ignore.**

[23] Williams, Colin F., Reed, Marshall J., Mariner, Robert H., DeAngelo, Jacob, Galanis, S. Peter, Jr., 2008, Assessment of moderate- and high-temperature geothermal resources of the United States: U.S. Geological Survey Fact Sheet 2008-3082, 4 p.

## Heat as a Valuable By-product (Decarbonization)

Where one finds excellent potential for geothermal electricity, they also find a significant source of low-cost, clean and renewable heat.

While geothermal electricity generation is an extremely viable proposition in its own right, often overlooked are the positive economic and social effects that can be gained from utilizing geothermal energy for direct use. While one is virtually limited by only their imagination in terms of what can be done with this potential, this section will focus on the environmental and geothermal heat opportunities.

CanGEA's previously released report on the direct use of geothermal heat details over 50 known applications.[24] With regards to Canada specifically, aquaculture operations, greenhouses, agricultural drying, hot springs, spas, industrial process heating, home heating, and snow melting, were in the opinion of CanGEA's experts, among the best-suited applications for the direct use of geothermal heat.[25]

Geothermal heat as a by-product of geothermal electricity generation is another tool for the province to use in combatting climate change. Geothermal heat is key to the process of decarbonization of the communities where there are geothermal opportunities. **There is a "2-for-1" value for capital cost, as building a single geothermal electricity plant effectively produces two "fuels": the electricity generated, and the heat, which can be used via a district heating system to either replace fossil-fuel-burning sources of heat in the community, or to replace electric heating, thus reducing the amount of electricity needed on the grid.**

Such reductions in heating costs allow for geothermal operations to be even more economical in colder climates, where fossil fuel heating would not be. In the "cold, dark winters" referred to by BC Hydro in their technical presentation, geothermal is not only a near-100% electricity capacity resource, but also an efficient source of heat.

The Canoe Reach and Lakelse Lake project sites were both chosen for (among many other reasons) the desire by the local communities (Valemount and the Kitselas First Nation near Terrace, respectively) to decarbonize by using geothermal heat.

Given how geothermal heat can be used in this way, it is reasonable to expect revenue from the heat can and will reduce the overall electricity costs. Assessments of the cost-effectiveness of geothermal electricity up to this point have not adequately considered the savings in dollars per MW due to this ancillary benefit. Furthermore, geothermal is a much cleaner electricity source,

[24] Bakhteyar et al., X.
[25] Ibid.

with much lower GHG emissions, considering it not only is clean in and of itself, but also reduces emissions elsewhere by providing by-product clean heat.

The Iceland Resource Park mentioned in the following section is another example of the added value of geothermal electricity. All aspects of the park are served by geothermal electricity and geothermal heat.

This is just one example of the potential ancillary benefits of geothermal heat as a by-product of geothermal electricity generation. There are many others, as illustrated in *Figure 4* below.[26]

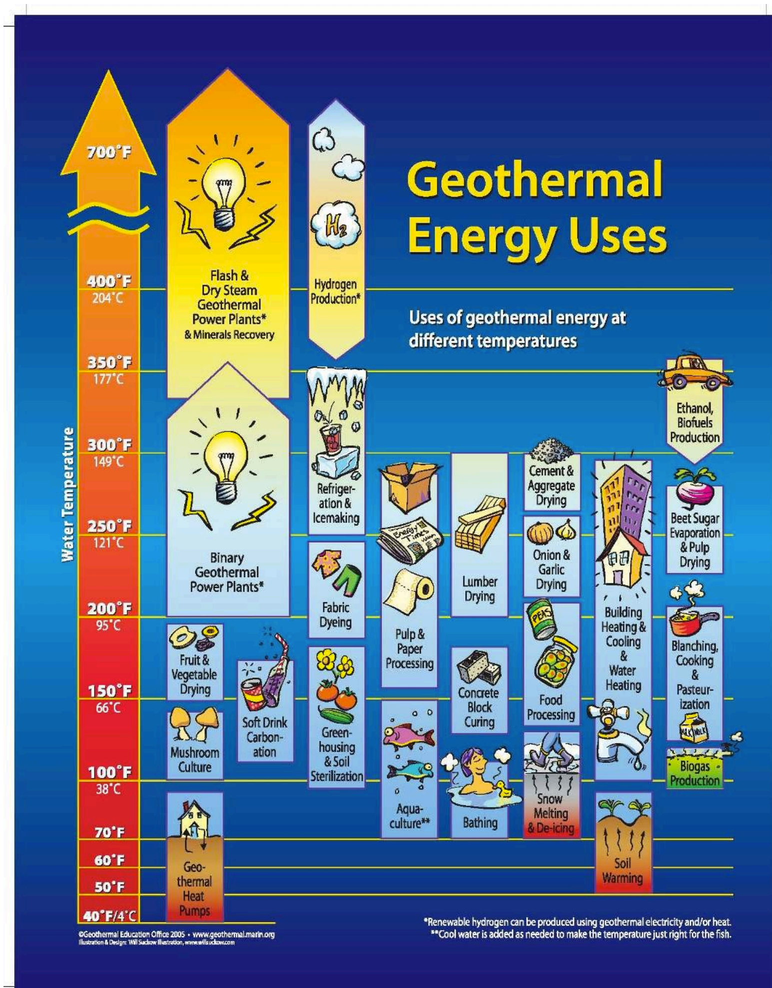



*Figure 4: Geothermal Energy Uses (GEO)*

[26] Geothermal Education Office (GEO), *Geothermal Energy Uses - Uses of geothermal energy at different temperatures* (2015), www.geothermal.marin.org.

## Employment Implications

In the original terms of reference for the Site C Inquiry, section 3(iv), the Commission was tasked with inquiring into whether another portfolio of generating projects "could provide similar benefits" as the Site C project. While the terms of reference specifically describe such benefits as firming, shaping, storage, etc., CanGEA believes it is important to point out the benefits to employment that can be provided by adding geothermal to an alternative portfolio, particularly compared to the Site C project. Implications for job creation may be seen by observing geothermal case studies in other jurisdictions like the United States and Iceland.

### United States Department of Energy Case Study

Geothermal energy production in the United States was $1.5-billion-dollar per-year industry in 2006.[27] In 1996, the U.S. geothermal energy industry as a whole provided approximately 12,300 direct and an additional 27,700 indirect jobs.[28] A 2017 estimate has attributed over 35,000 jobs in the geothermal industry.[29]

Table 2 (below) is useful to view the job-creating potential for geothermal energy in the United States. As per Table 2, geothermal energy produces 1.7 jobs per MW, thus at a 500 MW capacity, 850 permanent jobs are required for operation and maintenance.[30]

| Power Source | Construction Employment (jobs/MW) | O&M Employment (jobs/MW) | Total Employment for 500 MW Capacity (person-years) |
|---|---|---|---|
| Geothermal | 4.0 | 1.7 | 27,050 |
| Natural Gas | 1.0 | 0.1 | 2,460 |

*Source: Renewable Energy and Jobs – Employment Impacts of Developing Markets for Renewables in California, and based on California Renewable Technology Market and Benefits Assessment, Electric Power Research Institute, November 2001.*

Table 2: Comparative Job Creation, Electric Power Research Institute (2001)

[27] Geothermal Technologies Program, "Employment Benefits of Using Geothermal Technologies" U.S. Department of Energy, (January, 2006), pg 10, https://www.nrel.gov/docs/fy05osti/35939.pdf.
[28] Ibid, pg. 12.
[29] Daniel Lopez ed. Brian Lashier, "Fact Sheet: Jobs in Renewable Energy and Energy Efficiency (2017)," *Environmental and Energy Study Institute* (February 2017), http://www.eesi.org/papers/view/fact-sheet-jobs-in-renewable-energy-and-energy-efficiency-2017

[30] Geothermal Technologies Program, "Employment Benefits of Using Geothermal Technologies," pg. 12.

A 2016 report on geothermal energy production in the United States concluded that an additional 121,140 direct, indirect and induced jobs could be created if the full geothermal potential of nine western states was realized.[31] The report estimated that around 19,480 of these jobs would be full-time operational positions, and 101,300 would be temporary construction jobs lasting at least one year.

**Society Without Waste: Iceland Resource Park Case Study[32]**

The two HS Orka geothermal power plants, Svartsengi and Reykjanes, have a combined capacity of 175 MW.[33] In addition, HS Orka generates 150 MW of thermal energy for district heating in nearby municipalities.[34] The excess resource streams from the two HS Orka power plants are also employed by a variety of businesses, including: the Blue Lagoon, cosmetics manufacturers, biotechnology companies and aquaculture companies.

It is important to note that HS Orka produces 175 MW of power and functions with a staff of 60. The 840 other jobs within the Park make use of geothermal heat and other by-products from the power plant operations.[35]

The operation of the Resource Park has been developed on the basis of joint interests, such as the effluent from one company being raw material for another.

The objective of the Resource Park is to foster a "society without waste" and to ensure that all resource streams that flow to and from the companies in the Park are utilized to the fullest extent possible, in as responsible a manner as possible, for the benefit and further progress of the community.

**Geothermal Jobs in British Columbia**

Compare this with the Site C hydroelectric project, where the forecasted employment benefits of the project happen in one short and sudden burst. By BC Hydro's own estimates, only 160 permanent jobs will be created by the project following its construction.[36] By its own account, only 100 of these will be directly related to the project. This works out to 0.15 permanent jobs created per MW. More recently, in his Technical Presentation in front of the BCUC commission,

---

[31] Lopez, "Fact Sheet,"
[32] Information taken from: Resource Park, *Society without Waste*, Iceland Resource Park, accessed October 16, 2017, https://www.resourcepark.is/
[33] Magma Energy Corporation, *Iceland Operations and Properties*, accessed October 17, 2017, pg. 3, http://s1.q4cdn.com/340776418/files/Mag_Iceland%20properties-FEB%202011.pdf.
[34] Ibid.
[35] Resource Park, *Society without Waste.*
[36] Site C Clean Energy Project, "Environmental Impact Statement: Executive Summary" BC Hydro, (January, 2013): 21.

Rick Hendrik's stated that in fact only 74 permanent jobs were going to be created as a result of Site C, resulting in 0.07 permanent jobs per MW.[37]

*Chart 8* below provides a comparison of the Site C project with equivalent geothermal power projects in terms of job creation. In their support of Site C, BC Hydro claims that 33,000 temporary construction jobs will be created. While the dam will have very permanent effects upon large tracks of land that is altered by it, nearly all of the jobs that it will create will be temporary and disappear once the project is developed.

| Power Source | Construction Employment (jos/MW) | Operation & Maintenance Employment (jobs/MW) | Total Temporary Employment for 1,100 MW Capacity | Total Permanent Employment for 1,100 MW Capacity | Total Employment for 1,100 MW Capacity |
|---|---|---|---|---|---|
| Geothermal | 4 | 1.7 | 4,400 | 1870 | 6270 |
| Site C | 30 | 0.07 | 33,000 | 74 | 33,074 |

*Chart 8: Nameplate Comparative Employment from 1,100 MW*[38]

The development of 1,100 MW of geothermal energy would have quite different effects. While still substantial in comparison to other energy projects, 1,100 MW of geothermal power would create 4,400 temporary construction jobs.[39] In addition, according to the U.S. DOE, 1,100 MW of geothermal power would create 1,870 permanent jobs that are sustainable over the long-term. See *Chart 8 above*. It should be noted further that these jobs would be full-time.[40] Also worthy of consideration is the fact that this does not include any of the employment created by the utilization of geothermal heat, nor from the extraction of materials from geothermal brine.

---

[37] British Columbia Utilities Commission, *IN THE MATTER OF THE UTILITIES COMMISSION ACT R.S.B.C. 1996, CHAPTER 473 And British Columbia Hydro and Power Authority British Columbia Utilities Commission Inquiry Respecting Site C*, Technical Input Proceedings (Vancouver), October 14, 2017, pg. 1437-1438 line 26 and line 6, http://www.sitecinquiry.com/wp-content/uploads/2017/10/614_2017_10_14_BCH-Site-C-Vancouver-V14-full.pdf
[38] Adapted from: Geothermal Technologies Program (DOE) and Site C Clean Energy Project, 3.
[39] Geothermal Technologies Program, "Employment Benefits of Using Geothermal Technologies" U.S. Department of Energy, (January, 2006).
[40] Dan Jennejohn, "Green Jobs Through Geothermal Energy" Geothermal Energy Association (October, 2010): 7.

## Environmental Implications: Disturbed Land

Geothermal has the added benefit of using much less land than other renewable or non-renewable electricity sources. This has the effect of reducing overall cost by reducing the amount of land that must be permitted, as well as reducing the environmental footprint by reducing the amount of land that must be cleared. It is reasonable to conclude that a renewable source that uses minimal land, like geothermal does, is superior environmentally to the other alternatives.

Observe Table 3, describing a selection of geothermal plants in the United States, Guatemala, Nicaragua, Costa Rica, Turkey, and Japan. Note the very low land dimensions occupied per MW produced, averaging 0.3 hectares per MW.

| Plant Name | Capacity (MW) | Original Developer | Country | Dimensions (approx)* | ha/MW |
|---|---|---|---|---|---|
| Raft River Geothermal Plant | 16 | Ormat | Utah, USA | 200 m x 215 m | 0.27 |
| Blundell Geothermal Plant | 10.6 | Ormat | Utah, USA | 270 m x 350 m | 0.89 |
| Brady Geothermal Plant | 21 | Brady Power (subsidiary of Ormat) | Nevada, USA | 160 m x 300 m | 0.23 |
| Desert Peak Geothermal Plant | 12.5 | Brady Power (subsidiary of Ormat) | Nevada, USA | 325 m x 300 m | 0.78 |
| Soda Lake I Geothermal Plant | 5.1 | Magma Energy | Nevada, USA | 115 m x 80 m | 0.18 |
| Soda Lake II Geothermal Plant | 21 | Magma Energy | Nevada, USA | 250 m x 300 m | 0.36 |
| Aidlin Geothermal Plant | 17 | Calpine | California, USA | 160 m x 160 m | 0.15 |
| Bottle Rock Geothermal Plant | 15 | US Renewables Group | California, USA | 130 m x 170 m | 0.15 |
| West Ford Flat Geothermal Plant | 24 | Calpine | California, USA | 250 m x 175 m | 0.18 |
| MP-II Geothermal Plant | 15 | Ormat | California, USA | 180 m x 200 m | 0.24 |
| Ormesa IE Geothermal Plant | 10 | Ormat | California, USA | 160 m x 125 m | 0.2 |
| Zunil I Geothermal Plant | 31.5 | Ormat | Guatemala | 115 m x 160 m | 0.06 |
| Amatitlan Geothermal Plant | 20 | Ormat | Guatemala | 50 m x 50 m | 0.01 |
| Momotombo Geothermal Plant | 22 | Ormat | Nicaragua | 325 m x 225 m | 0.33 |
| Miravalles V Geothermal Plant | 18.1 | Ormat | Costa Rica | 125 m x 110 m | 0.08 |
| Tuzla Geothermal Plant | 7.5 | Ormat | Turkey | 120 m x 140 m | 0.22 |
| Dora 1 Geothermal Plant | 7.35 | Ormat | Turkey | 230 m x 150 m | 0.47 |
| Bereket Geothermal Plant | 6.9 | Ormat | Turkey | 200 m x 280 m | 0.81 |
| Ohdake Geothermal Plant | 12.5 | Kyushu Electric | Japan | 220 m x 165 m | 0.29 |
| Onikobe Geothermal Plant | 12.5 | J-Power | Japan | 115 m x 90 m | 0.08 |
| | | | | | |
| | | | | Average | 0.3 |
| OUTLIER | | | | | |
| Steamboat Hills Geothermal Power Plant | 14.5 | Ormat | Nevada, USA | 600 m x 675 m | 2.79 |
| | | | | | |
| Site C Hydroelectric Dam | 1100 | BC Hydro | BC, Canada | 56,610,000 m^2 | 5.15 |

*Table 3: USA & Global Geothermal Plant Capacity and Land Mass Dimensions (and Site C)*[41]

Unlike solar, wind and biomass, which are based upon gathering energy from "diffuse ambient energy over large tracts of land", geothermal energy utilizes a concentrated subterranean resource. As a result its physical footprint is considerably smaller.

---

[41] Site C Information Taken from: BC Hydro, *Evidentiary Update- 3.5.2 Updated Environmental and Economic Development Attributes (Table 17)*, BC Hydro for Generations (September 13, 2017).

Note also the inefficiency of the Site C project, weighing in at 5.15 hectares per MW generated, a significantly larger environmental footprint than geothermal electricity.

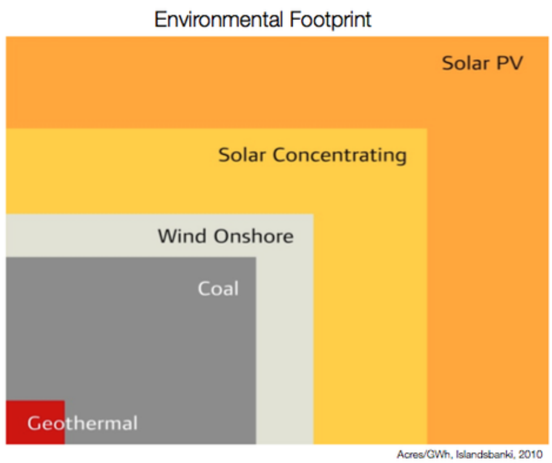



*Figure 5: Environmental Footprint for Various Techniques*

As the above figure shows, geothermal's physical footprint is tiny compared to other renewable and non-renewable sources. With low land use per MW generated, geothermal electricity can deliver a clean energy future with minimal environmental impact.

## Environmental Implications: Greenhouse Gas Emissions (GHGs)

Geothermal emits minimal greenhouse gases, while at the same time offering dispatchability and reliability. Over a 30-year period (the estimated site lifespan assigned by CanGEA in our calculations of production capacity and capital cost) geothermal binary closed loop electricity plants will produce negligible carbon dioxide emissions.

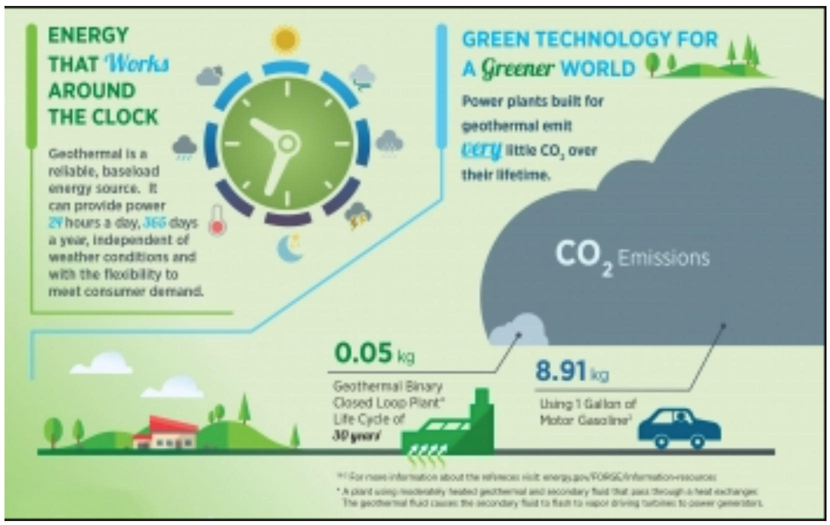



*Figure 6: Geothermal Energy GHG Emissions over 30 years (U.S. DOE)*

Figure 6[42] above reveals that **only 0.05 kg or 50 grams of $CO_2$ are emitted over a 30-year period and 167 grams over a 100-year period** for a Hydrothermal Binary Plant.

Conversely, Table 4[43] below contains an estimation of the $CO_2$ emissions intensity for various energy projects including Site C. The total emissions are presented in two manners, the conservative operations estimate and the likely operations estimate. The following two statements are references from Rick Hendrik's Technical Presentation to the British Columbia Utilities Commission on Saturday, October 14, 2017: (1) -The conservative operations estimate results in a total of 5.8 Mt (mega tonnes) of emissions over 100 years, with much of it occurring

---

[42] U.S. Department of Energy, *Energy that Works Around the Clock*, accessed October 18, 2017, https://energy.gov/sites/prod/files/styles/borealis_photo_gallery_large_respondsmall/public/Geothermal%20Infographic.jpg?itok=G6jwms55.

[43] Taken from: BC Hydro, *Submission to the British Columbia Utilities Commission Inquiry into the Site C Clean Energy Project- Appendix G*, BC Hydro Power Smart (August 30, 2017), http://www.sitecinquiry.com/wp-content/uploads/2017/09/DOC_90101_F1-1BCH_submission_SiteC_Public.pdf.

in the first 15 years (2) - The likely operations estimate results in a total of 4.3 Mt of emissions over 100 years, most in the first 10-15 years.[44]

| Generating Facility Type | Range (g $CO_2$e/kWh) | Average (g $CO_2$e/kWh) |
|---|---|---|
| Tropical Hydroelectric | 1,750 – 2,700 | 2,150 |
| Modern Coal | 959 – 1,042 | 1,000 |
| IGCC (coal) | 763 – 833 | 798 |
| Diesel | 555 – 880 | 717 |
| NGCC (Natural Gas) | 469 – 622 | 545 |
| Photovoltaic | 13 – 104 | 58 |
| Canada Boreal Hydroelectric | 8 – 60 | 36 |
| Wind Turbines | 7 – 22 | 14 |
| BC Hydro Site C (construction plus conservative operations estimate) | — | 14.3[a] |
| BC Hydro Site C (conservative operations estimate) | 2 – 212 (annual range)[b] | 11.4[c] |
| BC Hydro Site C (construction plus likely operations estimate) | — | 10.5[a] |
| BC Hydro Site C (likely operations estimate) | 2 – 146 (annual range) | 8.5[c] |

**NOTES:**
[a] Average emission intensity over 8 year construction and 100 year operating period.
[b] Figure 1 shows annual operating phase emissions would be highest at the outset and decline to low annual emission rate within 20 years
[c] Average emission intensity over 100 year operating period.

Intensities for Modern Coal, IGCC (coal), Diesel, NGCC (Natural Gas), Photovoltaic, and Wind Turbines include life cycle emissions. See IRN 2006. Intensities for Boreal and Tropical Hydroelectric facilities include only reservoir emissions.

— not available, however operating year 1 – 100 would be as shown for operations estimates

**Source:** IRN 2006

*Table 4: Emissions Intensity – Project Compared with Other Generation*

[44] British Columbia Utilities Commission, *Technical Input Proceedings – October 14,* 2017, Presenter: Rick Hendriks, UBC Water Governance Representative, pg. 1423 lines 1-4, http://www.sitecinquiry.com/wp-content/uploads/2017/10/614_2017_10_14_BCH-Site-C-Vancouver-V14-full.pdf.

## First Nations Support

It is important once again to mention the degree to which geothermal electricity as part of an alternative portfolio to Site C would be more respectful of the rights of local First Nations. It would also bring greater opportunity to engage with First Nations groups. Further, it would better fulfill the obligations of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

The two geothermal projects being developed by CanGEA members are both proceeding with the consent and cooperation of the nearby First Nations. **Most notably, Kitselas Geothermal Inc., a First-Nations-led company, is developing the Lakelse Lake project near Terrace.**

The Canoe Reach project near Valemount has received vocal public support from the Simpcw First Nation. In 2016 the Simpcw issued a public statement in support of the Canoe Reach geothermal project.[45] Additionally, in the summer of 2017, the Simpcw First Nation provided a letter of support for the project to the Ministry of Energy, Mines and Petroleum Resources.

Geothermal projects, particularly those being developed in BC by CanGEA member companies, have the advantage of greater consent and cooperation of First Nations. In its community engagement sessions across the province, the Commission has heard from several more First Nations communities, all of whom are in favour of geothermal.

---

[45] https://www.youtube.com/watch?v=z-OsBVAaD2Q retrieved August 28, 2017. Courtesy: Borealis Geothermal.

## Conclusion

As can be seen from the heat map on the cover of the CanGEA submissions, there are numerous areas across British Columbia with significant geothermal potential. We believe they can be developed at a reasonable LCOE and offer both capacity and energy, reliability, firming, and shaping.

CanGEA recommends that the Government of BC advise BC Hydro and Columbia Power Corp. to form industry partnerships with geothermal developers in order to develop geothermal resources most effectively. Columbia Power Corp., for example, is a natural partner particularly in South-East & Central BC.

CanGEA also requests that a CanGEA member be appointed to the boards of BC Hydro and Geoscience BC, so as to assist those organizations in achieving a true understanding of the benefits of geothermal and its place in BC's future electricity grid.

**CanGEA believes strongly that geothermal resources must be included in the Commission's alternative portfolio. The supporting data is on our side; a portfolio that includes geothermal is well suited to meet British Columbia's electricity needs.**

We would like to reiterate that the geothermal projects currently in development in BC (Lakelse Lake, Canoe Reach) should go ahead regardless of the Commission's Site C decision, because of the numerous benefits those projects provide. These projects can provide firm energy at a lower cost, on a timetable and in a manner that benefits taxpayers, ratepayers, First Nations, and the economy, all with a lower carbon footprint.

Warm Regards,

**Nathan Coles**
*BHum, JD*
Senior Policy Manager

**Zach Harmer**
*Master of Public Policy*
Operations Manager

On Behalf of CanGEA's Policy Team

*CanGEA associate Alex Kent, CanGEA Board Members Alex Richter (ThinkGeoEnergy) & Alison Thompson (management at Borealis GeoPower Inc. & board director at Kitselas Geothermal Inc.) contributed information to this submission.*

CanGEA
CANADIAN GEOTHERMAL ENERGY ASSOCIATION

CanGEA
CANADIAN GEOTHERMAL ENERGY ASSOCIATION

www.cangea.ca

info@cangea.ca

www.powearthful.org

powEARTHful