PROGRAM ON WATER GOVERNANCE

Site C Inquiry:

Submission #6 to the BC Utilities Commission

19 October 2017

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www.watergovernance.ca

This is the sixth submission by the University of British Columbia's Program on Water Governance to the BC Utilities Commission Inquiry Respecting Site C.

The Program on Water Governance (www.watergovernance.ca) is co-hosted by UBC's Department for Geography and Institute for Resources, Environment, and Sustainability. Dr. Karen Bakker, Professor and Canada Research Chair at the University of British Columbia, is the Co-Director of the Program.

The Program on Water Governance previously published five reports on Site C, which are available online (watergovernance.ca/projects/sitec/). In addition, several submissions have been made to the BCUC, including:

Document Title	BCUC ref number/ submission date	Suggested Reference
Reassessing the Need for Site C	F106-1 (August 2017)	Hendriks et al. (April 2017)
Comparative Analysis of Greenhouse Gas Emissions of Site C versus Alternatives	F106-1 (August 2017)	Hendriks (July 2016)
Submission to the British Columbia Utilities Commission regarding the Site C Hydroelectric Project	F106-2 (August 2017)	Raphals and Hendriks (August 2017)
An Updated Portfolio Present Value Cost Analysis of the Site C Project	F106-5 (October 2017)	Raphals and Hendriks (October 2017)
Policy Issues of Relevance to the Inquiry Respecting Site C	F106-6 (October 2017)	Hendriks and Raphals (October 2017a)
Comments on BC Hydro's Appendix M: "Flaws in Hendricks [sic] /Rafals [sic]/Baker [sic] ("UBC") Report"	F106-7 (October 2017)	Hendriks and Raphals (October 2017b)

In addition, two PowerPoint presentations were filed, following the authors' presentations at the Commission's Technical Conference on October 14, 2017:

Document Title	BCUC ref number/ submission date	Suggested Reference

Presentation: Policy Issues of Relevance to the Inquiry Respecting Site C	F106-8 (October 2017)	R. Hendriks (October 2017a)
Presentation: An Updated Portfolio Present Value Cost Analysis of the Site C Project	F106-9 (October 2017)	P. Raphals (October 2017a)

This current submission consists of two additional documents, prepared in response to the Commission's invitation (A-22):

Document Title	BCUC ref number/ submission date	Suggested Reference
Comments on the Commission's Draft Alternative Portfolio to Site C	F106-10 (October 2017)	R. Hendriks (October 2017b)
Alternative Portfolios with regard to the Site C Project	F106-11 (October 2017)	P. Raphals (October 2017b)

It should be noted that both documents of this current submission contain embedded spreadsheets.

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The authors are solely responsible for the report's contents. The report does not reflect the views of the University of British Columbia or of the funder.

Sincerely,

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Alternative Portfolios with regard to the Site C Project

Philip Raphals

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ABOUT THE AUTHOR

Philip Raphals is cofounder and executive director of the Helios Centre, a non-profit energy research and consulting group based in Montreal. Over the last 25 years, he has written extensively on issues related to hydropower and competitive energy markets, and has appeared many times as an expert witness before energy and environmental regulators in several provinces.

Mr. Raphals has been formally recognized as an expert witness by energy regulators in the provinces of Quebec, Nova Scotia and Newfoundland and Labrador:

- In Quebec, he has provided expert testimony in 14 proceedings before the Régie de l'énergie du Québec. The Régie has recognized his expertise in fields including transmission ratemaking, security of supply, energy efficiency and avoided costs;

- The Nova Scotia Utilities and Review Board has qualified Mr. Raphals as expert in sustainable energy policy, least-cost energy planning and utility regulation (including transmission ratemaking). He provided expert testimony in two proceedings there concerning the Maritime Link, including critical analysis of long-term demand forecasts, resource options and financial analyses submitted by NSP Maritime Link Inc., a subsidiary of Emera, in support of its proposal to build an undersea transmission link between Newfoundland and Nova Scotia, and the accompanying long-term electricity supply contracts. In its decision, the Board quoted Mr. Raphals' report and relied in part on his analyses;

- The Newfoundland and Labrador Public Utilities Board has qualified Mr. Raphals as an expert in electric utility rate making and regulatory policy. He has provided expert testimony in in 2011 Muskrat Falls Review and in its hearings on the 2013 General Rate Application of Newfoundland and Labrador Hydro.

Mr. Raphals is currently acting as an expert witness in rate proceedings before the Manitoba and Newfoundland and Labrador Public Utilities Boards.

Mr. Raphals appeared as an expert witness on behalf of Grand Riverkeeper Labrador Inc. in the hearings of the Joint Review Panel (JRP) on the Lower Churchill Generation Project, which relied on his analysis of project justification. The Panel cited him in its report and relied on his analyses for several of its findings.

In British Columbia, Mr. Raphals appeared as an expert witness on behalf of the Treaty 8 Tribal Association in the hearings of the Joint Review Panel on the Site C Hydroelectric Project. The Panel cited him in its report and relied on his analyses for several of its findings. He also presented expert affidavits in two related proceedings before the B.C. Supreme Court, one of which was not received by the Court.

From 1992 to 1994, Mr. Raphals was Assistant Scientific Coordinator for the Support Office of the Environmental Assessment of the Great Whale Hydroelectric Project, where he coauthored with James Litchfield and Roy Hemmingway a study on the role of integrated resource planning in assessing the project's justification.

In 1995, Mr. Raphals was commissioned by the Quebec Department of Natural Resources to prepare a report on electricity regulation in British Columbia, focussing on the structure and practices of the British Columbia Utilities Commission. The report formed part of the documentation supporting Quebec's Public Debate on Energy, which eventually led to the creation of the Régie de l'énergie.

In 1997, Mr. Raphals advised the Standing Committee on the Economy and Labour of the Quebec National Assembly in its oversight hearings concerning Hydro-Quebec. In 2001, he authored a major study on the implications of electricity market restructuring for hydropower developments, entitled *Restructured Rivers: Hydropower in the Era of Competitive Energy Markets*. In 2005, he advised the Federal Review Commission studying the Eastmain 1A/Rupert Diversion hydro project with respect to project justification. Later, he drafted a submission to this same panel on behalf of the affected Cree communities of Nemaska, Waskaganish and Chisasibi.

Mr. Raphals chairs the Renewable Markets Advisory Panel for the Low Impact Hydropower Institute (LIHI) in the United States. He has been an invited speaker before the Senate Standing Committee on Energy, the Environment and Natural Resources and at numerous energy industry conferences, including the Canadian Association of Members of Public Utility Tribunals (CAMPUT). He has also been an invited speaker at Yale University, Concordia University and McGill University.

In 2013, Mr. Raphals was an invited participant in an expert roundtable on electricity surpluses and economic development, convoked by the Quebec Commission on Energy Issues. The Commission's report relied on several of his analyses.

In 2015, he was a finalist for the R.J. Tremplin Prize, awarded by the Canadian Wind Energy Association for "scientific, technical, engineering or policy research and development work that has produced results that have served to significantly advance the wind energy industry in Canada."

Together with Prof. Karen Bakker of the University of British Columbia , and Rick Hendriks, Mr. Raphals was coauthor of "Reassessing the Need for Site C", a study published by the UBC Programme on Water Governance in April 2017.

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1 Introduction

In our earlier submission F106-5[1], we demonstrated the profound flaws in BC Hydro's 70-year rate analysis, due to its reliance on a great number of unsupported and unsupportable assumptions.

We urged the Commission to require that BC Hydro reveal the present value results of the 20-year System Optimizer analysis it has already carried out.

The Commission's "straw man" portfolio analysis, A-22, is also based on a 70-year horizon. We realize the intense time constraints under which the Commission is working, and understand that these portfolios were prepared at the same time as we were preparing F106-5.

While we continue to believe such a long analysis period is a serious obstacle to rigorous analysis, we see little choice but to work within the framework proposed by the Commission.

While the costs of Site C can be projected for 70 years (albeit with an unsupportable assumption that interest rates will remain at their historic lows for the duration), there is no way to know how much it will cost to repower a wind farm in 2054, or in 2074 – nor, indeed, the costs of any other resources to be acquired or renewed many decades from now.

BC Hydro's assumptions in this regard are extremely pessimistic. The Commission has made the more reasonable assumption that, upon repowering, the costs of a wind farm will fall by 30% in real terms.

BC Hydro's assumptions with regard to utility-scale solar power to geothermal power are also surprisingly pessimistic. The portfolio presented below relies in part on information presented by CanGEA regarding two particular geothermal projects, and on information presented concurrently by R. Hendriks concerning the recent trends in solar PV costs.

The decision to evaluate the costs of a block of power and energy corresponding precisely to Site C is also problematic, though we realize that the wording of s. 3(b)(iv) of the OIC can be read to call for this particular approach. This forces the replacement block to reproduce the surplus caused by Site C, foregoing the benefit of avoiding that surplus. The adjustments that this approach inevitably requires, when the alternate portfolio produces more or less energy than would Site C, can lead to biases and inaccuracies.

As we argued in F106-5, we believe it would be preferable to consider the full range of resources needed to meet energy and capacity demands, rather than this single slice. However, in this response to the Commission's invitation for comment on its Alternative

[1] Raphals, P. and Hendriks, R., An Updated Present Value Cost Analysis of the Site C Project (Oct. 2017).

Portfolios, we have remained as close as possible to the form of the Commission's Alternative Portfolio Spreadsheet, changing only the resource choices.

Unfortunately, those spreadsheets were very difficult to work with, as many of the formulas had been replaced with numbers, making it difficult to retrace the underlying logic. Furthermore, the way the sheets were structured made it difficult to explore other combinations of resources that could provide equivalent service at lower cost.

We have prepared an alternate version of the the Commission's spreadsheet portfolio model, based on the assumptions and approaches described below. We have modified its organization, in order to improve its usefulness as a research tool. However, most of the Commission's assumptions remain intact, as well as its approach to calculation of cost of service.

In the available time, we have only been able to implement this for the medium load forecast. However, if the Commission would allow a supplemental submission, we can provide spreadsheets for the high and low forecasts within a day or two.

2 Comments on the assumptions underlying A-22

As noted in A-22, "The illustrative Alternative Portfolios are designed to replace only Site C energy and capacity used for domestic consumption… To the extent that they result in generation that is surplus to BC Hydro's requirements (for example, as a result of ramping up DSM energy savings), it is assumed that this surplus energy is exported and the value of exports is treated as a credit to the cost of the illustrative Alternative Portfolio." (page 2)

As noted above, we have concerns about this approach, but accept it as a workable approach in the present context.

We provide the following comments regarding the assumptions detailed in A-22:

Discount rate: We have used the discount rate proposed by BC Hydro.

Financing costs: While we disagree with BC Hydro's use of 100% debt financing for evaluating resource alternatives, but use that assumption for the purposes of this exercise.

Taxes: In the absence of clear indications as to the taxation rate to be applied for Grants in lieu of taxes and school taxes (GIL/ST), we have omitted them.

Size of the Alternative Portfolio: We have accepted the Commission's approach of sizing the Alternative Portfolio to replace Site C energy and capacity used for domestic consumption, despite the reservations expressed elsewhere.

Location of Alternative Portfolio: We have followed the Commission's approach of using a "plant gate" cost. However, for geothermal and solar resources, it was not possible to site them in the Peace Valley region. We have assumed that transmission costs and losses are roughly similar between the producing regions.

Energy surplus to BC Hydro need: We find the Commission's assumption of a constant plant gate export price of 2018 $25/MWh (based on a forward market price of US$30/MWh at MidC) to be unnecessarily simplistic. Instead, we rely on the market price forecast in the RRA.[2] However, we retain the adjustments proposed by the BCUC, including losses (1.9%), wheeling costs (CA$6.3/MWh), and 11% losses to Site C (or equivalent) plant gate. We do not make any adjustment for a) risk premiums inherent in forward market prices (since we do not rely on them), b) risk of limited available transmission capacity (as BC Hydro has testified that it has no such constraints), or c) risk of future downward prices from renewables, as these should be incorporated in the market price forecast.

Capacity surplus to BC Hydro need: We follow the BCUC assumption of no additional value (i.e., no capacity export market), as we find unpersuasive BC Hydro's assertions that such a market is about to come into existence. BC Hydro has substantial surplus capacity during most hours of the year, and has yet to succeed in monetizing that surplus.

Energy exceeding Site C: We have followed the Commission's method of proportionally reducing annual costs of the Alternate Portfolio to the extent that generation exceeds Site C generation.

Capacity exceeding Site C: We have followed the Commission's method of crediting $50/kW-yr for capacity exceeding the capacity of Site C which is required for meeting BC needs.

Energy focused DSM: Like the BCUC, we have used the additional costs and savings flowing from using the IRP DSM portfolio instead of that found in the RRA. We have also explored, as an option, the use of the IRP PLUS DSM portfolio, again using its marginal costs and savings in relation to the RRA figures.

Capacity-focused DSM: We have used the Commission's value of $75/kW-yr for industrial containment. However, we have treated it as an expense, recovered in the year when it is used, rather than deferring and amortizing these costs over 15 years. While we have been unable to identify their precise source, we have used the costs and savings for capacity-focused DSM programs (including but not limited to demand response) included in the A-22 spreadsheet.

Battery storage: As noted in F106-3 at page 35, we find BC Hydro's estimated future costs for Li-ion battery storage to be excessively pessimistic. We propose instead a cost of $1000/kW in 2020. However, this option is not selected in the mid-load portfolio presented here.

Exchange rate: We have used the Commission's proposed exchange rate of CA$1/US$0.7979.

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[22] BCUC 2.310.1.

Greenhouse gas emissions: For the reasons described in F106-6, section 3, we find that the alternative portfolio has greenhouse gas emissions substantially lower than those of Site C.

3 Approach and design of the spreadsheet portfolios

In order to allow evaluation of a variety of resource choices, we have somewhat reorganized the spreadsheet. The workbook is for the medium load forecast only. If the Commission will allow a supplemental submission, similar workbooks for the high and low load forecasts can be provided by within a day or two.

Our version includes the following tabs (from left to right):

Energy and capacity gap: Reproduced unchanged from A-22.

Energy and capacity balance: In rows 3 through 20, the user can choose the supply-side resources, indicating for each one its:

- Name
- In-service date
- Installed capacity
- Cost ($/kW)
- Useful life
- Capacity factor
- Capacity value (the % of installed capacity that can be counted in the capacity balance)
- Expected price reduction at repowering
- Expected price reduction due to technological advancement
- Fixed O&M

Resource	fiscal years	MW	$/kW	M $	life		cap. Facto	cap. Value	efurb disc	provmnt d	$/kW-yr
Wind - PC 18 (138 MW)	2028				25		32.50%	26%	30%	10%	66
Wind - PC 14 (144 MW)	2029				25		32.50%	26%	30%	10%	66
Wind - PC 20 (156 MW)	2030	156	1903	297	25		32.50%	26%	30%	10%	66
Wind - PC 28	2031	153	1904	291	25		32.50%	26%	30%	10%	66
Geothermal - Canoe Reach (58 MW)	2025	58	5172	300	25		95%	100%	30%	10%	213
Geothermal Lakelse Lake (23 MW)	2025	23	5217	120	25		95%	100%	30%	10%	213
Solar PV - SE BC or Peace Valley	2025	100	1029	103	25		17%	24%	30%	10%	23
Solar PV - SE BC or Peace Valley	2030	250	1029	257	25		17%	24%	30%	10%	23
Solar PV - SE BC or Peace Valley	2032	250	1029	257	25		17%	24%	30%	10%	23

To the right, in columns U through X, the NPV values of the portfolio (DSM component, supply-side component, and total, including energy adjustment) are shown.

Rows 23 to 26 show the year-by-year energy balance, starting with the gap to fill (row 23), the supply-side and DSM energy contributions (rows 24 and 25), and the resulting surplus or deficit (row 26). A limit can be indicated in cell B26; for any year (F2018 - F2094) in which the deficit is greater than this limit, the cell will appear red.

Similarly, the capacity balance is calculated in rows 35 to 41. Year-by-year entries for Industrial Curtailment (row 38, up to 100 MW) and market reliance (row 39, up to 300 MW) must be made manually. Any values below zero appear red.

Useful excess capacity (i.e., that occurs when the utility is not in surplus) appears in row 41, giving rise to a capacity credit (assumption 9 of A-22).

DSM Cost of Service: Year-by-year DSM investments are shown in rows 17 to 21. The values for the IRP DSM plan, over and above that which was included in the RRA (the base case), are drawn from BCUC 2.64.0, Attachment 1, and are shown in row 17. The investment values for capacity-focused DSM and for "TOU" (including demand response) are taken from A-22 ("Med LF – portfolio", lines 8 and 9). A toggle at cell K20 (in yellow) allows the user to include or not the additional DSM according to BC Hydro's "IRP DSM PLUS" package.

Rows 25 to 30 show the energy savings resulting from these DSM investments, and rows 34 to 39, the capacity savings. (These values feed back into the "Energy and capacity balance" tab.)

Rows 54 to 80 calculate the depreciation and annual balances of these DSM investments, using depreciation calculations borrowed from A-22.

Similarly, their cost of service is calculated in rows 287 through 297.

Year-by-year costs related to industrial curtailment and market reliance are added in rows 298 and 299, with a total in row 300, which is carried forward to the supply-side CoS tab.

Supply-side cost of service: In rows 20 through 137, this tab calculates the year-by-year capital costs for each supply-side resource chosen on the "energy and capacity balance" tab. Capital costs are summarized in rows 141 through 151.

Operating costs plus surplus sales revenues are calculated in rows 180 through 185, and brought up to row 154.

Grants-in-lieu and school taxes are imported directly from A-22, and so are undoubtedly incorrect, as the formula for calculating them was not made explicit.

The credit for useful overcapacity (assumption 9 in A-22) is calculated on the "energy and capacity balance" tab, and brought in to row 160. Adding it to capital costs and O&M costs produces the annual supply-side cost of service (row 161), which is added to the DSM cost of service (row 163), for an overall cost of service.

The "energy adjustment" for energy exceeding Site C (assumption #8 of A-22) is applied to this amount, yielding the "Total Generation and DSM Cost of Service (assuming only amount of build used to replace Site C is included)". The present value of this cash-flow stream represents the overall cost of the portfolio, and is reported back to the top of the "energy and capacity balance" tab.

Two additional tabs provide data used in the above: **DSM data** and **price forecast data.**

The **“DSM data”** tab is derived from BCUC 2.64.0, Attachment 1.

The “**price forecast data”** tab relies on data provided in IR BCUC 2.310.1 from the RRA, with the adjustments described in assumption #6 of A-22.

4 An alternate portfolio at lower present value cost

Using the tool described above, we have identified a portfolio that meets energy and capacity needs under the medium load forecast at a present value cost lower than the $2,889 million identified in A-22.

The portfolio consists of:

- The IRP DSM plan, plus capacity focused DSM and “optional TOU rate”, as per A-22;
- Industrial curtailment of 50 to 100 MW, used in F2025 through F2030;
- Capacity market reliance of up to 225 MW, used in F2025, F2026 and F2029;
- The Canoe Reach and Lakelse Lake geothermal plants, both in service in F2020, with the following characteristics[3]:

Name	Installed capacity	$/kW	$ M	Capacity factor	Fixed O&M ($/kW-yr)
Canoe Reach	58 MW	$5,172	$300	95%	$213
Lakelse Lake	23 MW	$5,217	$120	95%	$213

- Wind project PC20 (156 MW) in service in F2030;
- Wind project PC2 (153 MW) in service in F2030;
- 100 MW of utility-scale solar PV, located in southeastern B.C. or in the Peace Valley, in F2025, at a cost of US$821/kW installed, with fixed O&M of $23/kW-yr[4];
- an additional 250 MW of utility-scale solar PV in F2030; and
- 250 MW of utility-scale solar PV, located in the southeastern B.C. or in the Peace Valley, in F2032.

In this portfolio, forecast capacity needs — or rather, capacity corresponding to that of Site C — are met by a combination of supply- and demand-side resources. The two geothermal projects that come on line in F2025 provide 91 MW of firm capacity. The 309 MW of wind projects that come online in F2030 and F2031 provide another 78 MW of effective load carrying capability, and the solar projects are assumed by BC Hydro to provide 24 MW of ELCC for each 100 MW installed. In addition, demand-side resources, including voluntary industrial curtailment and

[3] CanGEA, Comments on Alternative Portfolios (Oct. 18, 2017), page 10.

[4] See Hendriks, R., Comments on the Commission’s Draft Alternative Portfolio to Site C, Oct. 18, 2017, section 2.1.2.

demand response, as well as the capacity value of traditional DSM, also provides hundreds of megawatts of peak capacity.

The present value of this portfolio is $2,188 million, or $701 million less than the portfolio identified by the Commission in A-22.

It is our hope that this tool will facilitate examination by the Commission of other combinations of resources, based on its analysis of the characteristics of each.

5 Conclusion

Using a reorganized version of the spreadsheet model provided by the Commission as part of A-22, we have a developed an alternate portfolio to replace Site C under the mid load forecast scenario. It is hoped that this reorganized spreadsheet will be of use to the Commission in completing its analyses regarding the Site C Project. With the Commission's permission, we will submit alternate scenarios for the high and low load forecasts within a day or two.

This portfolio retains only two of the four wind projects included in the Commission's draft portfolio, and neither of the battery storage projects. Instead, it includes two geothermal projects identified by CanGEA, as well as three utility-scale solar installations, starting in F2025.

Using these resources, together with occasional capacity market reliance and industrial curtailment, **it is possible to replace Site C for a present value cost of $2,188 million, or $701 million less than the portfolio identified by the Commission in A-22.**

Compared to the full cost of Site C, with an NPV of $3,623 million, this alternative portfolio is obviously attractive. It is even superior to BC Hydro's "sunk cost" scenario, with an NPV of $2,346 million. However, if the comparison is made to BC Hydro's "sunk cost and termination costs" scenario, with an NPV of just $1,776 million, the alternative appears to have a somewhat higher cost. As we have stated earlier in our submissions, we believe that a comparison to BC Hydro's "sunk cost and termination costs" scenario is inappropriate. Sunk costs should be treated as sunk. The question before the Commission is, rather: would termination or continuation lead to lower overall costs? Our results indicate the former.

There are two other key considerations we wish to raise in closing. First, there is no reason to expect the ratepayer to assume 100% of the sunk costs and the termination costs of Site C, since, in bypassing the British Columbia Utilities Commission, the regulatory compact — whereby ratepayers must live with the consequences of decisions in which they have had a voice — was not respected. If even part of these costs fall to the shareholder, rather than the ratepayer, then the alternative portfolio appears to be clearly superior.

Second, the option value resulting from being able to adapt to changed circumstances in the future is significant, but left out of these present value analyses. How does one quantify the benefit that results from being able to adapt to changing circumstances (or — the other side of the coin — the cost of being locked into a single 70-year strategy)?

If we try to predict how the world will evolve over the next 70 years, the unknowns are far greater than the knowns. The ability to react to changing events may turn out to be much more significant than calculations based on questionable assumptions.