SITE C CLEAN ENERGY PROJECT

VOLUME 1 APPENDIX D

NEED FOR AND ALTERNATIVES TO THE PROJECT

SUPPORTING DOCUMENTATION

PART 4 – PORTFOLIO ATTRIBUTES

July 2013

BC hydro
FOR GENERATIONS

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PRIMARY AUTHOR

Michael Savidant

Commercial Manager, Site C

1 INTRODUCTION

This appendix provides an overview of the technical, financial, environmental and economic development attributes of the portfolios created for the analysis of alternatives to the Project. This appendix provides further details on the attributes discussed in Section 5 of the EIS and in the Technical Memo on Alternatives to the Project.

The technical, financial, environmental and economic development attributes are described in Section 5.5.1 of the EIS. Section 5.5.2 of the EIS provides an overview of the attributes of the available resource options that are considered in the portfolio analysis. As outlined in Section 5.5.4.1, the three categories of portfolios that were considered were:

- **Site C Portfolios** that <u>include the Project</u>, with the remaining energy and capacity gap being filled using clean or renewable generation resources.
- **Clean Generation Portfolios** that <u>exclude the Project</u> and fill the energy and capacity gap using clean or renewable generation resources. As referenced in Section 5.5.2, available clean or renewable resources for portfolio purposes are wind, run-of-river, and biomass to provide energy and capacity, with pumped storage providing backup capacity but representing an energy consumer.
- **Clean + Thermal Generation Portfolios** that <u>exclude the Project</u> and fill the energy gap using clean or renewable generation resources as in the Clean Generation Portfolio, while backup capacity is provided by thermal generation (in the form of SCGTs) up to the 93% clean or renewable target, as well as pumped storage.

The attributes provided in this appendix are generally based on the 5,100 GWh/1,100 MW block of power from the Clean Generation and Clean + Thermal Generation portfolios[1]. Appendix 3 of the Technical Memo on Alternatives to the Project provides a list of the individual resource options making up the Clean and Clean + Thermal portfolios. The portfolio attributes summarized in Section 5.5.4 of the EIS and further described below are calculated by combining the attributes of these individual resource options.

The purpose of the resource option attributes is to permit planning level comparisons of the three categories of portfolios. The environmental attributes are the most difficult to apply at a planning level given that site specific information for available resources is not available. BC Hydro developed the environmental attributes in conjunction with Hemmera Envirochem Inc., Kerr Wood Leidal Associates Ltd. and HB Lanarc Consultants. The environmental attributes were also reviewed by the B.C. Ministry of Environment. The environmental attributes are not designed for purposes of undertaking a formal environmental assessment[2] of the available alternatives to the Project; this is untenable given that neither the specific alternatives nor their site specific information is available for these alternatives. This point is expanded upon below in section 4.1 of this appendix.

[1] The one exception is the Portfolio PV provided in the Financial Attributes section, which is based on the System Optimizer output. See Section 5.5.3 of the EIS for an explanation of the portfolio modeling framework.

[2] E.g., assessing each of the available alternatives as if they individually triggered the B.C. *Environmental Assessment Act* and/or the *Canadian Environmental Assessment Act*.

2 TECHNICAL ATTRIBUTES

Table 1 Technical Attributes

Indicator	Unit of Measure	Classifications	Clean Portfolio	Clean + Thermal Portfolio	Project Portfolio
Energy	GWh	Average annual energy	5,220	5,190	5,100
		Firm Energy Load Carrying Capability	5,160	5,130	4,700
Capacity	MW	Dependable Generating Capacity (DGC)	1,110	1,120	1,100
		Effective Load Carrying Capability (ELCC)	1,420	1,390	1,100
		Installed (nameplate) capacity	2,470	2,320	1,100
Variability	None (Qualitative)	Hourly / daily / monthly variability	No numerical results to report		
Note: All values rounded to nearest 10					

The Clean and Clean + Thermal portfolios created as described in Section 5.5.4.1 of the EIS were built to have firm energy and dependable generating capacity approximately equivalent to the Project based on BC Hydro's generation energy and capacity planning criteria as described below[3]. The criteria are used to evaluate when generation resources are required to maintain a reliable and adequate supply of electricity to meet load. As all portfolios had the similar levels of these technical attributes, technical attributes were not reported further in Volume 1 Section 5.5.4.

Generation Energy Planning Criterion

For predominantly hydroelectric utilities, the energy planning criterion is important because fuel supply (water) is limited. BC Hydro's generation energy planning criterion, prior to the CEA self-sufficiency requirement was to meet its energy requirements with firm energy plus some degree of reliance upon non-firm hydro energy backed up by market purchases. Firm energy is defined as the ability to meet load requirements under the most adverse sequence of stream flows in respect of BC Hydro Heritage hydroelectric assets occurring within the 60-year period between October 1940 and September 2000.

The CEA self-sufficiency requirement modifies the generation energy planning critera that BC Hydro would otherwise have in place. The pre-self-sufficiency energy planning criterion establishes the firm energy reliance that BC Hydro could place on particular types of resources including how much non-firm hydroelectric energy backed up by market purchases are appropriate. The *CEA* self-sufficiency requirement establishes 2 additional requirements: (1) the reliance upon the heritage assets under a prescribed water condition which has been set as average water[4] and (2) that all other resources must be located in within the Province.

[3] Due to the discrete nature of the resource options used to make up the portfolios, the energy and capacity in the Clean and Clean + Thermal portfolios do not precisely match the Project's 5,100 gigawatt hours per year (GWh/year) and 1,100 megawatts (MW). These differences do not materially affect the other attributes

[4] Average water conditions are used to calculate the mean annual Heritage hydroelectric energy output over the 60-year period between October 1940 and September 2000.

By prescribing average water conditions for Heritage hydroelectric assets and that all other reliance must be from provincial resources effectively sets the degree to which BC Hydro can rely upon non-firm hydro energy backed up by market purchases at 4,100 GWh/year. As a result, the Heritage hydroelectric planned reliance is based upon average water capability and the planned reliance on all other resources is based upon their firm energy capability.

The energy reliance for each of BC Hydro's Heritage hydroelectric resources, thermal projects and Electricity Purchase Agreements (EPAs) with independent power producers (IPPs) for clean or renewable intermittent available resources such as run-of-river hydro and wind, and also for biomass, is determined by application of the self-sufficiency and firm energy requirements described below.

BC Hydro Heritage Hydroelectric Resources

For BC Hydro's Heritage hydroelectric resources, the *Electricity Self-Sufficiency Regulation*[5] requires BC Hydro to achieve self-sufficiency by 2016 and each year after that assuming that the Heritage hydroelectric resources are capable of producing no more than what they can produce under average water conditions. The Project is classified as a Heritage hydroelectric resource. Thus the Project's average annual energy output is appropriate for use in comparing available alternatives.

The generation capability of BC Hydro's Heritage hydroelectric resources during the lowest water inflows on record (known as 'critical water conditions') is the referred to as the firm energy load carrying capability (FELCC) of the system. The difference from critical water conditions to average water conditions is an additional reliance on the Heritage hydro system non-firm energy, backed up by market reliance in F2017 of about 4,100 GWh/year.

Thermal Resources

Firm energy from thermal resources such as natural gas-fired generation is the energy capability based on conservative estimates of plant availability factors or expected plant operation factors. Plant availability or operational factors are typically based on historical operation experience or, where applicable, industry statistics of similar facilities. Note that for SCGTs, BC Hydro plans upon an 18% capacity factor for firm energy reliance to be consistent with expected operations of a peaking plant.

EPAs

For IPP hydroelectric resources, BC Hydro uses the firm energy contribution to the system under critical water conditions (the most adverse sequence of stream flows occurring within the same 60-year period described above in respect of BC Hydro Heritage hydroelectric assets). With the degree of market backup established in the Heritage hydro reliance and further restricted by the self-sufficiency requirement, IPP non-firm energy from hydroelectric resources does not meet BC Hydro's energy planning criterion and is not relied upon to meet customer demand.

For wind and biomass resources, their average energy production is relied upon for firm energy contribution since their year-to-year variability is typically much lower and is independent of hydro inflows.

[5] B.C. Reg. 315/2010, as amended by Order in Council No. 036 (B.C. Reg. 16/2012, deposited 3 February 2012).

Generation Capacity Planning Criterion

The generation capacity criterion is designed to ensure that there is sufficient installed generation capacity to reliably serve the instantaneous demand of the BC Hydro integrated system. BC Hydro applies a standard Loss of Load Expectation (**LOLE**) methodology for its evaluation of capacity reliability. An 'adequate' generation system is defined as one that has an annual expectation of being unable to serve the daily peak demand of less than one day in ten years. The one day in ten years LOLE methodology has widespread use in the industry. For the BC Hydro system as a whole, the one day in ten years criterion requires installed dependable capacity to exceed peak load by approximately 14 per cent (about 1,800 MW in F2021).

Resource availability is an important aspect of the LOLE methodology. BC Hydro uses dependable capacity to define the resource availability. Dependable capacity, measured in MW, is the amount that resources are capable of supplying to meet the instantaneous peak load for electricity with a high level of confidence. DGC is used for resources that provide dependable capacity, such as the Project, biomass and natural gas-fired generation (Simple Cycle Gas Turbines (SCGTs)).

Similar to the generation energy planning criterion discussed above, the CEA self-sufficiency requirement modifies the generation capacity planning criterion. Prior to the CEA self-sufficiency requirement, BC Hydro has relied upon 400 MW of dependable capacity from the markets in its long term planning. The CEA self-sufficiency requirement requires all of the generating facilities to be within the province; hence, there is no reliance on external market capacity to meet the generation capacity planning criterion.

ELCC is an attribute that includes a potential capacity contribution from intermittent resources such as wind and run-of-river hydro which provide little dependable capacity. Use of ELCC and the possibility that it may overstate the capacity contributions of intermittent clean or renewable resources is discussed at section 5.2.1.2 of the EIS. Qualitative discussion of resource variability is provided in Section 5.2, with further discussion in Section 7.4.1 and 7.4.3.

3 FINANCIAL ATTRIBUTES

As discussed in Section 5.5.1.1, financial attributes describe the cost of resource options. For the purposes of portfolio analysis, BC Hydro considered the overall cost of the portfolio of resource options to BC Hydro ratepayers.

There were two main financial attributes:

- The **present value (PV) of portfolio costs**, presented as the difference in PV between the Project portfolio and the alternatives. As stated in Section 5.5.4.2, "[t]his represents the financial benefits of the Project over the 30-year analysis period." PV calculations were performed for both F2022 and F2024 Project in-service dates.
- The **adjusted unit energy cost (UEC)** of the portfolios. As stated in Section 5.5.4.2, "[t]his adjusted UEC represents the present value of the amount BC Hydro's customers pay per unit energy delivered, and is a proxy for the financial benefits over project life."

Financial attributes for portfolios are, unless otherwise stated, provided in F2013 dollars.

Table 2 provides the financial portfolio attributes. As indicated by the green shading, all financial attributes were provided in the portfolio analysis discussion in Section 5.5.4.1 of the EIS (see Table 5.41 and 5.43).

Table 2 Financial Attributes

Indicator	Unit of Measure	Classifications	Clean Portfolio	Clean + Thermal Portfolio	Project Portfolio
Portfolio Cost PV	$ millions	Project in-service date F2022	450	(150)	n/a
		Project in-service date F2024	660	180	n/a
Adjusted UEC[6]	$/MWh	n/a	181	156	110
Note: All values rounded					

[6] UEC values include transmission-related costs to deliver electricity to the Lower Mainland (BC Hydro's main load center), wind integration costs, greenhouse gas (GHG) compliance instrument (e.g., offset) costs for SCGTs, soft costs to reflect the fact that implementing any of the available resource options would trigger costs related to mitigation, First Nation consultation and if appropriate accommodation, public engagement and regulatory review, and costs of capacity backup for intermittent clean or renewable resources that provide little dependable capacity, and exclude Project sunk costs. Please refer to section 5.5.1.1 of the EIS for further detail.

4 ENVIRONMENTAL ATTRIBUTES

For ease of reference, environmental attributes for the portfolios have been divided.

4.1 Land and Freshwater Attributes

Table 3 provides the portfolio attributes related to terrestrial and freshwater ecosystems. Items shaded in green were provided as part of the portfolio analysis discussion in the Section 5.5.4.4 of the EIS (see Table 5.43).

Table 3 Environmental Attributes: Land

Indicator	Unit of Measure	Classifications	Clean Portfolio	Clean + Thermal Portfolio	Project Portfolio
Land Attributes					
Land Footprint[7]	Hectares	n/a	2,230	2,430	5,660
Net primary productivity ($gC/m^2/year$)	hectares (ha) per class	Low (0 to < 69)	50	60	-
		Medium (69 to < 369)	1,670	1,770	2,280
		High (> 369)	510	600	3,380
Remoteness – linear disturbance density (km/km^2)	ha per class	Wilderness (< 0.2)	850	1,010	3,070
		Remote (0.2 to < 0.66)	200	200	480
		Rural (0.66 to 2.2)	670s	680	1,360
		Urban (> 2.2)	510	540	750
High priority species count (percentile)	ha per class	0 to < 20	225	200	-
		20 to < 40	840	770	-
		40 to < 60	400	340	-
		60 to 80	190	350	-
		> 80	580	770	5,660
Freshwater Attributes					
Affected stream length	kilometres (km)	n/a	15	15	125
Reservoir aquatic area	Ha	n/a	-	-	9,300
Priority fish species (number of priority fish species per watershed)	ha per class	No priority species (0)	70	70	-
		Low species diversity (1 to 12)	170	30	-
		Moderate species diversity (13 to 23)	1,980	2,320	5,660
		High species diversity (24 to 38)	0	0	-
Note: All values rounded					

The project footprint is broken down by classification levels based on classification data sets. Land footprint is broken down into net primary productivity, linear disturbance density and high priority species count; the land footprint is also broken down for the priority fish species freshwater attribute.

[7] All land attributes shown in Table 3 are based on the same footprint for the resource options making up the portfolio.

BC Hydro provided the overall footprint on land and freshwater in the analysis of alternatives provided in Section 5.5.4 due to the level of uncertainty regarding the type and siting of the resources making up the Clean and Clean + Thermal portfolios. As stated in Section 5.5.4.4:

> "The environmental attributes for the Project are unique compared to the alternatives shown as a result of the advanced level of project definition for the Project, which allows for a higher level of accuracy in determining the Project footprint. The portfolios without the Project are populated with forecast "typical" projects with estimated footprints. As a result, the differences in environmental attributes between portfolios shown in [section 5.5.4.4] compare a defined attribute for the Project to a representative estimate for IPPs."

There is uncertainty in the overall portfolio footprint due to the uncertainty in the potential portfolio composition. For the attributes with an additional layer of categorization, further uncertainty is introduced due to the uncertainty in the potential siting of these resources. Should a number of resources be developed in a different part of the province than the portfolio results assume, the split of the project footprint by classification could be significantly different.

There is additional uncertainty in the attributes with an additional layer of categorization due to the nature of the classification input data. The datasets used to determine the classification for the attributes are at a coarse scale due to their high-level nature. In addition, for attributes based on sampling activities (i.e., the land and freshwater priority species attributes), accuracy may vary by species and by region due to differing levels of sampling activity. This results in land and freshwater attributes that may not be indicative of actual conditions at the location of a specific resource options – an issue that is compounded with the uncertainty in the type and location of resource options in portfolios.

The additional layer of classification in the additional attributes results in an implication of environmental assessment where no assessment has been completed. For example, a project with a footprint in the "40 to < 60" classification of the High Priority Species attribute would indicate the project affected between 40 and 60 priority species – however there has been no assessment of whether these species would be, in fact, affected by the project at all.

Due to the significant uncertainties outlined above, BC Hydro determined that the attributes with additional categorization were insufficiently predictive of the potential actual impacts of the resource options to be used in the comparison of portfolios. The high-level attributes of land footprint, affected stream length and reservoir area have a lower level of uncertainty, and were therefore used in Section 5.5.4 as a meaningful basis for comparison of portfolios.

4.2 Atmosphere Attributes

Table 4 below provides the GHG and air contaminant attributes for the portfolios. Items shaded in green were provided as part of the portfolio analysis discussion in Section 5.5.4.5 of the EIS (see Table 5.43).

Table 4 Environmental Attributes: Atmosphere

Indicator	Unit of Measure	Classifications	Clean Portfolio	Clean + Thermal Portfolio	Project Portfolio
GHG emissions	tonnes/year, thousands	Carbon dioxide equivalent	200	650	-
Air	tonnes/year,	Sulphur dioxide	0.1	0.1	-

contaminant emissions	thousands	Oxides of nitrogen (NO_x)	0.5	0.6	-
		Carbon monoxide (CO)	0.4	1.3	-
		Volatile organic compounds	0.0	0.0	-
		Fine particulates: $PM_{2.5}$	-	-	-
		Fine particulates: PM_{10}	0.1	-	-
		Fine particulates: PM total	0.2	0.0	-
		Mercury	0.0	0.0	-
Note: All values rounded					

Both GHG and air contaminant emissions were estimated for operating phase emissions associated with fuel combustion (that is, for natural gas-fired generation (SCGTs), and wood-based and municipal solid waste biomass resources). As a result, the GHG and air contaminant attributes associated with wind, run-of-river hydro and the Project are zero in the portfolio analysis. A full assessment of the life-cycle GHGs of the Project may be found in Volume 2 Section 15 Greenhouse Gases.

GHG emissions was used for portfolio comparison in Section 5.5.4 due to the importance of GHG reductions as reflected in Subsection 2(g) of the *Clean Energy Act*, which references the Province of British Columbia's legislated GHG reduction targets for the years 2012, 2016, 2020 and 2050 (see Section 5.3.2 of the EIS).

BC Hydro selected the NO_x and CO attributes for the purposes of portfolio comparison. These were the two air contaminants with the highest levels of emissions during operations. In addition, NOx and CO are ozone precursors, and ozone is known to have health effects when above certain concentrations. It was determined that the additional air contaminants were not material to the comparison of portfolios, and as a result they were excluded from further consideration.

4.3 Marine Attributes

Table 5 below provides the portfolio attributes related to marine ecosystems. No resource options selected in the portfolios had a material marine footprint. As a result, marine attributes were not provided in the discussion in Section 5.5.4 of the EIS.

Table 5 Environmental Attributes: Marine

Indicator	Unit of Measure	Classifications	Clean Portfolio	Clean + Thermal Portfolio	Project Portfolio
Valued ecological features (number of valued ecological features)	ha per class	None (0)	-	-	-
		Low (1 to 2)	-	-	-
		Medium (3 to 5)	-	-	-
		High (> 5)	-	-	-
Key commercial bottom fishing areas	ha per class	No bottom fisheries	-	-	-
		1 bottom fishery	-	-	-
		2 to 3 bottom fisheries	-	-	-
		> 3 bottom fisheries	-	-	-

5 ECONOMIC DEVELOPMENT ATTRIBUTES

Table 6 provides the economic development attributes for the portfolios. This consisted of the increase in provincial Gross Domestic Product (GDP), the increase in employment and the increase in provincial revenues due to Project spending. These attributes were provided for both the discrete construction period as well as the ongoing operations period. Items shaded in green were provided as part of the portfolio analysis discussion in the Section 5.5.4 of the EIS (see Table 5.44).

Table 6 Economic Development Attributes

Indicator	Unit of Measure	Classifications	Clean Portfolio	Clean + Thermal Portfolio	Project Portfolio
Provincial GDP – Construction Period	Dollars, millions	Direct	580	450	760
		Indirect	1,640	1,450	2,250
		Induced	390	330	530
		Total	2,610	2,230	3,530
Provincial GDP – Operations Period	Dollars, millions per year	Direct	50	30	10
		Indirect	40	80	0
		Induced	20	20	0
		Total	110	130	10
Employment – Construction Period	Jobs	Direct	7,390	5,790	9,750
		Indirect	21,000	18,610	28,000
		Induced	4,840	4,110	6,500
		Total	33,230	28,520	44,250
Employment – Operations Period	Jobs per year	Direct	420	300	30
		Indirect	550	540	30
		Induced	200	180	20
		Total	1,180	1,020	70
Provincial Revenue – Construction Period	Dollars, millions	Direct	90	70	120
		Indirect	230	205	310
		Induced	50	45	70
		Total	375	320	500
Provincial Revenue – Operations Period	Dollars, millions per year	Direct	25	25	5
		Indirect	10	10	0
		Induced	0	0	0
		Total	30	40	5
Note: All values rounded					

The differences in economic development attributes are generally consistent across all indicators and classifications, although they vary between the construction and operations phases. As a result, to simplify the analysis BC Hydro selected three economic development attributes as indicative of the construction and operations attributes of the portfolios. These were (as indicated in green shading in Table 6): the total provincial GDP increase during construction, the total employment increase during construction and the total employment increase during operations. Further attributes were not material to the comparison of portfolios.