BC Sustainable Energy Association Position on the Site C Hydro-Electric Project, November 2014

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I. Site C Decision

This fall, the government of BC will decide whether to approve the construction by BC Hydro of the 'Site C Clean Energy Project.' Site C is a hydro-electric dam and generating station on the Peace River that would contribute 5,100 gigawatt-hours

(GWh) of electrical energy and 1,100 megawatts (MW) of capacity per year to the BC Hydro system.

In its 2013 Integrated Resource Plan, BC Hydro assessed Site C and other possible resource options in relation to forecast energy and capacity needs over the next twenty years. BC Hydro concluded that Site C is needed for its earliest practical in-service date of 2023.[1]

The BC Sustainable Energy Association has closely followed BC Hydro's resource planning since 2006, including planning for Site C, and offers this position.

A. BCSEA's position on Site C and recommendation to government

The BC Sustainable Energy Association calls on the BC government to postpone a final decision on the proposed Site C project.

The government should order BC Hydro to update its Integrated Resource Plan (IRP) and submit it to the BC Utilities Commission for a thorough public review.[2] There should be a complete re-examination of BC Hydro's 20-year electricity needs and the best ways to meet those needs, taking into account enhanced energy efficiency measures, wind and solar power, the advantages of smaller generating projects throughout the province compared to a single mega-project, and the optimal timing of any new generating projects.

B. Reasons

BCSEA recognizes that BC Hydro has demonstrated a need for more electrical power over the next twenty years. We recognize that Site C would be able to meet this need effectively and without significantly increasing BC's greenhouse gas emissions. We also recognize that Site C offers a valuable power product, with dispatchable capacity to meet peak loads, to firm up intermittent sources of generation, and to profit from trading opportunities.

However, there are significant reasons for the government not to approve Site C:

- BC Hydro's evaluation of Site C and alternative options is out of date and should not be relied on without first being updated and thoroughly tested in

[1] *Integrated Resource Plan*, BC Hydro, November 2013, p. 1-24. "F2024" means "Fiscal 2024," i.e. the twelve month period ending on 31 March 2024, based on BC Hydro's fiscal year. The 2013 IRP was approved by the BC government in November 2013. https://www.bchydro.com/energy-in-bc/meeting_demand_growth/irp/document_centre/reports/november-2013-irp.html#sthash.tQYv6t29.dpuf

[2] An amendment to the *Clean Energy Act* will be required in order to restore the role of the Utilities Commission (as opposed to the government) to review and approve the BC Hydro IRP.

a public review process conducted by the Utilities Commission. Energy efficiency and conservation has great potential to reduce the need for additional generation. Technologies like wind and solar power are rapidly developing and becoming more cost-competitive. In addition, BC Hydro needs to update the 20-year load forecast, given the large uncertainties about BC Hydro's future electricity loads.[3] BC Hydro should update the IRP based on all this new information,[4] and the government should have the BC Utilities Commission conduct an independent public review of it.

- Also, the potential benefits of major technological developments like battery storage should be considered for their potential to affect long term planning and grid operation.

- Site C is a gigantic mega-project. All its economic and social impacts would occur in a single area of the province. Once in service, it would create an immediate oversupply of electricity, in contrast to smaller projects, which could be brought into service to match the timing of the need. BCSEA believes that more overall economic and social benefits, including local partnership opportunities, would be achieved with smaller but more numerous energy developments located in different areas of the province and built when the need for the power materializes.

- In BCSEA's view, it would be financially imprudent for the government to approve Site C based only on BC Hydro's own in-house cost estimate. The estimated cost of such a large project as Site C should be given independent public scrutiny by the Utilities Commission. That is what the Commission is for.

- BCSEA recognizes that Treaty 8 and other First Nations have rights that would need to be addressed and appropriately accommodated. Should this not be achieved, Site C should not proceed.

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[3] *Integrated Resource Plan*, BC Hydro, November 2013, Section 2.2, BC Hydro's Load Forecast, pp. 2-1 to 2-17.
[4] BC Hydro already intends to update its IRP in the Fall of 2015. *BC Hydro Service Plan 2014/15-2016/17*, BC Hydro, 2014, page 35. http://bcbudget.gov.bc.ca/2014/sp/pdf/agency/bch.pdf

II. Analysis and conclusions

A. Sustainable energy criteria to assess Site C and alternatives

BCSEA assessed Site C from a sustainability perspective, considering energy planning and cost effectiveness issues, and also considering non-energy sustainability issues:

- Cost-effectiveness, including cost risk and the cost of alternative resources,
- Energy system benefits, such as energy, capacity and ability to firm up intermittent generation,
- Economic benefits, including employment,
- Greenhouse gas emissions reductions and other environmental effects, including inundation of agricultural land, and
- First Nations rights.

B. Cost effectiveness – cost risk

BC Hydro estimates the cost of Site C at $7.9 billion dollars.[5] However, this is BC Hydro's in-house estimate (albeit reviewed by a third party), and in BCSEA's view, it should not be relied on for so large a project.[6] With a large, complex, multi-year megaproject like Site C, there is a substantial risk that the cost would be higher – perhaps much higher – than BC Hydro's estimate.[7] This risk would be borne by BC Hydro's ratepayers. BCSEA says the government should have the Utilities Commission perform an independent public review of the Site C cost estimate.

IPP (independent power producer) alternatives to Site C carry a smaller cost risk for BC Hydro ratepayers. BC Hydro purchases electricity on long-term contracts from

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[5] *Site C Clean Energy Project Environmental Impact Statement*, BC Hydro, 2012: Volume 1, Appendix F, Part 1, page 1. http://www.ceaa-acee.gc.ca/050/document-eng.cfm?document=85328

[6] The *Report of the Joint Review Panel, Site C Clean Energy Project, BC Hydro*, May 2014, says (page 280), "… the [cost estimate] has been done to the standards of a Class 3 (-15 percent to +30 percent) estimate … and that the work has been reviewed independently by KPMG, a consulting firm." The panel goes on to say that it cannot reach a conclusion on the accuracy of the estimates due to lack of information, and it recommends that the BC Utilities Commission be tasked with making a detailed examination. The panel notes that BC Hydro has no recent experience with building a project as large as Site C, and has recently experienced cost over-runs averaging 3.3 percent for projects over $50 million. http://www.ceaa-acee.gc.ca/050/documents/p63919/99173E.pdf

[7] Large hydro-electric dams seem to be prone to up-side cost risk. Between the 1930s and the present, large dams built in North America have had mean cost over-runs of 11%, (versus 104% for other parts of the world), apparently as a result of various factors of systematic bias. See: *Should we build more large dams?* Ansar, Flyvbjerg, Budzier, Lunn, Energy Policy, 2013, page 6, paragraph 4. Granted, other resources are subject to project capital cost risk, too, as well as fuel price risk.

IPPs who develop the generation projects and assume the cost risk, albeit with a premium included in the contracted purchase price.

C. Cost effectiveness – the cost of alternative resources

BCSEA acknowledges BC Hydro's extensive work to estimate the costs of Site C and potential alternatives to Site C. However, this work needs to be re-done with updated information on the cost of these potential alternatives, and subjected to a public review.

BC Hydro's modeling in its 2013 Integrated Resource Plan (IRP) shows that adding Site C to its 'Clean Generation Portfolio' would save between $630 and $880 million in present value dollars compared to a Clean Generation Portfolio without Site C.[8]

However, this financial modeling has not been properly tested by the BC Utilities Commission in a public proceeding. Interested parties have not been able to probe the analyses with information requests or to provide their own evidence and analyses for scrutiny. BCSEA supports a legislative change to return BC Hydro's resource planning to the oversight of the Utilities Commission, giving the Commission the power to approve or reject BC Hydro's plan. Alternatively, the government could refer Site C and the IRP to the Commission, to hold an inquiry with public and First Nations participation, leading to recommendations to the government.

As discussed below, energy efficiency and conservation, wind power, and solar power may all offer cost effective alternatives to Site C. (This is not meant as a comprehensive listing of alternatives.)

Demand-side Management

Demand side management (DSM) refers to energy conservation and efficiency produced by BC Hydro's Power Smart programs and conservation rate structures. DSM can substantially reduce the amount of energy (and capacity) required to meet customers' needs. DSM can be very cost effective and has inherent advantages over supply-side (generation) resources. It avoids environmental disruption, does not require ongoing energy inputs and reduces the need for transmission infrastructure. BCSEA believes conservation and efficiency should be prioritized for consideration before new generation resources.

In Utilities Commission proceedings in 2012 and again in 2013, BCSEA and the Sierra Club of BC provided expert evidence that BC Hydro could cost effectively double its planned DSM savings. The evidence showed that BC Hydro could achieve

[8] *Integrated Resource Plan*, BC Hydro, November 2013, p. 6-43, Table 6-9. The range of cost estimates depends on external factors such as economic growth and natural gas prices.

9,000 GWh per year of additional load reductions, which is almost double the annual energy that would be provided by Site C. They stated:[9]

> … there is ample evidence that BC Hydro could double the scale of savings it currently plans, at costs that, while higher than BC Hydro has experienced thus far, would still be highly cost-effective.[10]

In moving from its 2012 Draft IRP to the final 2013 IRP, BC Hydro reduced its DSM spending plans even further. According to BCSEA and Sierra Club of BC:

> In pursuing conservation Option 2 rather than Option 3, BC Hydro plans to achieve 1,100 GWh/y less of energy savings by Fiscal 2021, although the average total resource cost (TRC) for Option 3 savings is $35/MWh, well below the $88/MWh unit energy cost for Site C and BC Hydro's proposed long-run marginal cost (LRMC) of $85 - $100/MWh.[11]

BCSEA believes that a thorough scrutiny of DSM opportunities could identify highly cost effective resources in sufficient quantities to displace the need for Site C.

Wind power

Wind power is in commercial operation in BC and many other parts of the world. Wind generation technology continues to advance in efficiency and cost effectiveness, due to improved engineering design and economies of scale in the wind turbine industry.

BC Hydro estimates the unit energy cost of BC wind resources at $115/MWh and up, compared to $88/MWh for Site C.[12] The most cost effective wind resource is assessed to be in the Peace River region, with some 6,000 GWh/year being developable at a cost (adjusted[13]) of from $115 to about $125/MWh.[14] This

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[9] See Exhibit C-10-13, *Direct Testimony of John Plunkett* in the BCUC review of BC Hydro's F2012-14 Revenue Requirements Application and DSM Expenditure Schedule Application. See also BCSEA-SCBC's *Comments on BC Hydro's May 2012 Draft Integrated Resource Plan*, pp. 10 & 11, submitted in BC Hydro's stakeholder consultations on its 2012 Draft Integrated Resource Plan. See: http://www.bcuc.com/Documents/Proceedings/2012/DOC_30377_C10-13_BCSEA-evidence.pdf

[10] Exhibit C-10-13, *Direct Testimony of John Plunkett* in the BCUC review of BC Hydro's F2012-14 Revenue Requirements Application and DSM Expenditure Schedule Application, pp. 7 & 8.

[11] *Integrated Resource Plan*, BC Hydro, November 2013, Appendix 7K, page 34: BCSEA's *Comments on BC Hydro's 2013 Integrated Resource Plan*, 18 October 2014.

[12] *Ibid*, Appendix 3A-1, Table 6-1, page 210, or Chapter 3, Table 3-26, page 3-72.

[13] *Ibid*, Appendix 3a-34. BC Hydro compares resource options on the basis of unit costs that are adjusted for various factors that affect the value of the resource to BC Hydro's system, including, as applicable: delivery to the lower mainland load centres, time of delivery, soft

represents a tranche of energy comparable to the 5,100 GWh/year (average) of Site C,[15] at a premium of about 36 percent above Site C's estimated cost.

However, these wind cost estimates have been challenged. Clean Energy BC commissioned a report by London Economics International that questions BC Hydro's analysis on topics such as project capital costs, project economic life, cost of capital and risk of cost overruns.[16] The report considers various renewable energy and conservation resources and concludes that a renewable energy portfolio of 65 percent wind and 34 percent run-of-river hydro would be less costly than Site C over its life.[17]

For international context, it is notable that Lazard, an international financial advisory and asset management firm, estimates the levelized, unsubsidized cost of wind power in the US to be in the range of $CAD 42 to 92/MWh,[18] unadjusted.[19]

In addition, BC Hydro assigns a $10/MWh cost to integrate wind power onto the grid, based on a detailed analysis performed in 2010.[20] If this cost were revisited, based on 15-minute, rather than hourly, scheduling requirements and the improving accuracy of day-ahead wind forecasts, the estimated integration cost could be substantially lowered.

Solar power

Solar photovoltaic (PV) power is now being deployed around the world, both at the scale of individual buildings and at utility scale. BC Hydro estimates the cost of utility scale PV at $341/MWh and up[21] (adjusted[22]), based on its 2010 Resource Options Report assessment.[23]

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costs, delivery during the spring freshet period, cost of incremental firm transmission, line losses, GHG offsets, capacity credit and wind integration. See the 2013 IRP, Chapter 3, Table 3-26, page 3-72 for a side-to-side comparison of unadjusted and adjusted resource option unit energy costs.

[14] *Ibid*, interpretation of data from Appendix 3A-1, Table 5-5, page 111, Figure 5-6, page 112, Table 6-1, page 201, and Figure 6-1, page 211.

[15] *Ibid*, Appendix 3A-1, page 140.

[16] *Cost-effectiveness evaluation of clean energy projects in the context of Site C*, London Economics International LLC, 2014.
http://www.cleanenergybc.org/media/LondonEI_20141016(1).pdf

[17] *Ibid*, Table 14, page 25, and abstract. The abstract reports savings of $750 million to $1 billion over the 70 year life of Site C, i.e. $11 - $14 million per year.

[18] *Lazard's Levelized Cost of Energy Analysis–Version 8.0*, Lazard, September 2014, page 2. http://www.lazard.com/PDF/Levelized Cost of Energy - Version 8.0.pdf. The costs in $US cited in the document have been converted here at a rate of $US 1 = $CAD 1.14, as of November 2014.

[19] Unadjusted costs are not directly comparable to adjusted costs. See footnote 13.

[20] *Integrated Resource Plan*, BC Hydro, November 2013, page 3-45, and Appendix 3E.

[21] *Ibid*, p. 3-72, Table 3-26.

However, the cost of new PV installations has been declining rapidly around the world. In the United States and Germany, utility scale PV is estimated to cost $CAD 148/MWh[24] and $CAD 110 to 170/MWh,[25] respectively (unadjusted[26]). Lazard estimates the unsubsidized, levelized cost for utility scale PV in the US at $CAD 82 to 98/MWh, albeit for the best geographic regions.[27] The reasons for the decline in the cost of solar power are similar to those for wind power: technological improvements and development of the industry, including increasing production of PV collectors in China and South Korea. BCSEA believe BC Hydro should update its cost estimate for PV, including a forward-looking assessment of the likely cost of PV at points in the future when energy shortfalls will occur.

Geothermal electrical generation

Geothermal electrical generation is a mature technology that can provide reliable and cost effective base load power, if a viable site can be found. During the time it would take for BC Hydro to update its IRP and the Utilities Commission to review it, further studies could be conducted to prove out this resource. Geoscience BC has just tendered a request for proposals to assess the economic viability of geothermal resources in BC.

Gas-fired generation

Some parties have advocated gas-fired generation as an alternative to Site C, citing resource costs estimates in the range of $57 to $86/MWh[28] (adjusted). BCSEA opposes any increase in the use of fossil fuel based generation. This would be inconsistent with BC's legislated GHG emissions targets, and inconsistent with the urgent need to reduce GHG emissions in order to mitigate the harmful effects of

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[22] See footnote 13 for a discussion of adjusted and unadjusted energy costs.
[23] *Integrated Resource Plan*, BC Hydro, November 2013, Appendix 3A-1, page 14. BC Hydro updated its data for some conservation options, wood-based biomass, wind, hydro power, "Resource Smart," and gas-fired generation, but apparently not for solar PV.
[24] *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014* (website posting), U.S. Energy Information Administration, April 2014. http://www.eia.gov/forecasts/aeo/electricity_generation.cfm
The table shows US $130 for PV, unsubsidized and US $118/MWh subsidized. These are converted here at a rate of $US 1 = $CAD 1.14, as of November 2014.
[25] *Levelized Cost of Electricity: Renewable Energy Technologies*, Fraunhofer Institute for Solar Energy Systems, November 2013, page 4. http://www.ise.fraunhofer.de/en
The table shows € 0.08 – 0.12/kWh for solar PV. Costs shown in Euros are converted here at a rate of €1 = $CAD 1.4, as of November 2014.
[26] Unadjusted costs are not directly comparable to adjusted costs. See footnote 13.
[27] *Lazard's Levelized Cost of Energy Analysis–Version 8.0*, Lazard, September 2014, page 2. http://www.lazard.com/PDF/Levelized Cost of Energy - Version 8.0.pdf. The costs in $US cited in the document have been converted here at a rate of $US 1 = $CAD 1.14, as of November 2014.
[28] *Integrated Resource Plan*, BC Hydro, November 2013, Table 3-26, page 3-72.

climate change. BCSEA does not recognize carbon offsets as providing reliable or credible mitigation of GHG emissions.

D. Energy system benefits – capacity

BCSEA accepts that BC Hydro will need to procure additional capacity resources by some time around 2020, with or without the addition of liquefied natural gas loads to BC Hydro's system.[29] (Capacity, as distinct from energy, is the amount of electricity that can be generated at a given moment, e.g. to meet peak loads on the system. Capacity is measured in watts, kilowatts (kW), megawatts (MW), etc. Energy is measured in kilowatt-hours (kWh), megawatt-hours (MWh), etc.)

Site C would help to address the upcoming need for additional capacity. It offers 1,100 MW of a superior power product, with a large amount of reliable and dispatchable capacity, which can be used to meet peak system demands, to firm up intermittent sources of generation, and to profit from trading opportunities. The location of Site C downstream from the Williston Reservoir means that Site C would benefit from BC Hydro's carefully optimized release of water from that reservoir, and would be operated in a coordinated manner with the other two generating facilities on the Peace River, the G.M. Shrum Generating Station and the Peace Canyon Project.[30]

However, other capacity alternatives – such as wind power and DSM – are available to meet BC Hydro's forecast need, although it is acknowledged that capacity from wind and DSM is less valuable because wind and DSM cannot be dispatched.[31] Some additional points:

- The 1,100 GWh/y of additional DSM savings referenced above would reduce BC Hydro's capacity requirements by roughly 200 MW, based on an assumed capacity factor of 60 to 70 percent. The 9,000 GWh/y figure for DSM would reduce capacity requirements by about 1,500 MW.

- Capacity focused energy conservation and efficiency measures and industrial load curtailment could provide about 950 MW of reduced capacity requirements.[32] BC Hydro omitted these from its current Integrated Resource Plan on the grounds that they are too uncertain.[33] However, they could be piloted and vigorously advanced.

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[29] *Ibid*, Appendix 9A, Table 4, page 9A-8 and Table 6, page 9A-12 show a need to make market purchases of capacity in Fiscal 2019.
[30] *Site C Clean Energy Project Environmental Impact Statement*, BC Hydro, 2013, Volume 1, section 7.4.1, page 7-20.
[31] *Integrated Resource Plan*, BC Hydro, November 2013, Table 6-40, page 6-35. See Appendix 9A tables for proposed in-service dates.
[32] *Ibid*, interpretation of Figure 3-5, page 3-28.
[33] *Ibid*, section 3.7.4, page 3-89.

- Acquiring 6,000 GWh/y of wind power, as discussed above (page 6), would bring a capacity addition ('Effective Load Carrying Capacity') of about 500 MW.[34]

- The 500 MW Revelstoke Unit 6 project, currently proposed for Fiscal 2030 or 2031 could be advanced for a F2021 in-service date.

- The 220 MW G.M. Shrum Units 1-5 upgrades, currently proposed for F2024 could be advanced to F2021.

- Energy storage is a rapidly advancing field of research, with significant investments and regulatory effort being applied to develop storage resources that can help to stabilize the power grid and reduce the need for excess generation capacity to meet peak loads. BC Hydro's assessment of its capacity needs should include a forward-looking assessment of potential technological developments in this field that could affect the relative value of Site C.

- BCSEA opposes the use of gas fired generation to meet capacity needs. As noted above, fossil fuel based generation increases GHG emissions, contrary the BC's legislated reduction targets and contrary to the urgent need to reduce GHG emissions and mitigate climate change.

E. Energy system benefits – firming intermittent energy

Because Site C is a highly dispatchable resource it would be able to compensate for the intermittent nature of renewable resources such as wind power and allow more renewable resources to be added to the system in the future. BC Hydro estimates that it can currently integrate 3,000 MW of wind capacity onto its system and that Site C would add 900 MW to this.[35] Accordingly, in the long term (i.e. after Site C's in-service date), Site C could help to increase the amount of renewable energy that could be integrated onto BC Hydro's system. However, acquiring Site C's energy would have the effect of postponing BC Hydro's need to acquire new energy resources like DSM, wind and solar power, at least within the time-frame of the IRP.[36]

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[34] *Ibid*, Appendix 3A-1, interpretation of data on Table 5-5, page 111 and Table 3-1, page 33. A 6,000 GWh/y tranche of energy in the Peace region would have an installed capacity of about 1,950 MW. BC Hydro reckons that wind power has an effective load carrying capacity (ELCC) of 26 percent.
[35] *Ibid*, section 6.4.5.2, page 6-64.
[36] *Ibid*. See Appendix 9A for a schedule of forecast resource acquisitions by year.

Significantly, there has been no opportunity to test BC Hydro's analysis. Wind integration and maximum practical penetration levels of intermittent generation are active areas of research and development in the United States and Europe.[37] An updated and publicly reviewed assessment of the wind integration capability of BC Hydro's system would help to put an appropriate value on Site C's potential firming contribution.

F. Economic benefits from employment

According to BC Hydro, Site C would generate 12,400 person-years of direct employment during its approximately seven year construction phase, and 60 full-time jobs during its operation.[38] By contrast, an equivalent amount of wind power could generate 22,500 person-years of direct jobs during construction and 300 full-time jobs during operation, according to the Canadian Wind Energy Association.[39] Solar photovoltaic (PV) projects appear to offer similar employment profiles to wind.[40] A study by KPMG commissioned by Clean Energy BC found 31,500 direct construction jobs and 149 direct jobs during operations for a basket of wind, biomass and small hydro projects.[41] The KPMG study also found $4.3 billion in direct and indirect GDP benefits during construction, versus BC Hydro's estimate of $3.2 billion in GDP benefits during construction.[42]

These results should be interpreted with caution, as the industry estimates have not been subjected to a public review. However, the results show that a thorough review of economic benefits by the BC Utilities Commission is needed.

Qualitatively, Site C's large size, single location and lack of ability to be phased would concentrate economic and employment benefits in time and location. BCSEA believes that greater overall economic and social benefits, including local

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[37] For example, the Utility Wind Integration Group (http://variablegen.org/resources/) posts research on and discussion of the integration of wind and other renewable energies onto utility grids.

[38] *Site C Clean Energy Project Environmental Impact Statement, Executive Summary*, BC Hydro, 2013, page 21, https://www.sitecproject.com/about-site-c/site-c-project-components

[39] *WindVision 2025*, Canadian Wind Energy Association (CanWEA), page 9. http://canwea.ca/pdf/windvision/Windvision_summary_e.pdf

[40] *Renewable Energy and Jobs*, International Renewable Energy Agency (IRENA), 2013, page 42. Solar PV employment for a project of equivalent capacity to Site C (1,100 MW) would cause 21,000 manufacturing, construction and installation (MCI) jobs, and some 275 operations and maintenance jobs. http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=377

[41] *Economic and Social Impacts of the Clean Energy Sector in BC*, 2014, KPMG, pp. 10-11.

[42] *Site C Clean Energy Project Environmental Impact Statement, Executive Summary*, BC Hydro, 2013, page 20, https://www.sitecproject.com/about-site-c/site-c-project-components

partnership opportunities with communities and First Nations, would be achieved with smaller, more numerous energy developments that could be spaced out, both geographically and over time.

Judith Sayers, former chief of the Hupacasath First Nation in Port Alberni, makes the case for distributed, rather than concentrated development, from a First Nations perspective, including skills development, business partnership participation, distributed benefits, community engagement and social license:

> Benefits from the Site C dam will likely be comprised of a financial settlement that will not reflect the immense loss each First Nation affected will feel isn't sufficient. It will also have elements of employment and procurement opportunities.
>
> Benefits from renewable energy projects [instead of Site C] will be the building of sustainable businesses within the values of the First Nations impacted, capacity being built in developing projects, members being trained to construct and operate these projects, revenues created from their own project, managing resources within their own territories and setting the environmental standards. Community pride and economic independence cannot be measured in monetary value.[43]

G. Environmental effects – GHG and climate change

Site C would cause direct GHG emissions from the flooding of land and the resultant methane production from the decay of vegetation, from motor vehicle emissions of carbon dioxide during construction and from the curing of concrete for the generator station. However, Site C's lifetime GHG emissions per unit of energy would be very low relative to those of fossil fuel based generation and comparable to those of wind and PV power.[44]

H. Environmental effects – other effects, including agricultural land

Site C would flood valley-bottom wildlife habitat that is relatively rare in that part of BC. Bull trout and arctic grayling, among other fish, would be harmed. The Joint Review Panel (JRP) for the environmental assessment of Site C concluded that grizzly, fisher, caribou, moose, elk, white-tailed deer and mule deer would not be significantly affected, but migratory birds would be harmed by the loss of valley

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[43] *How Do Benefits from Site C vs. Renewable Energy Projects Compare for First Nations*, Judith Sayers, October 2014. https://fnbc.info/blogs/judith-sayers/how-do-benefits-site-c-vs-renewable-energy-projects-compare-first-nations

[44] *Site C Clean Energy Project Environmental Impact Statement, Executive Summary*, BC Hydro, 2014, page 23. BC Hydro's analysis gives 8 g CO_2equivalent/kWh for Site C, versus 545 g CO_2e/kWh for natural gas generation, 14 g CO_2e/kWh for wind, and 58 g CO_2e/kWh for PV.

bottom habitat, and fishers could suffer cumulative effects.[45] The JRP concluded that Site C would make "small changes to the hydrology of the Peace River, and such changes would be attenuated by the time the flows reach Peace River, Alberta."[46]

However, the JRP did not find that there would be large harmful effects on outdoor recreation and tourism in the region.[47]

Some, e.g. the David Suzuki Foundation, have tried to assess the Peace Valley in ecosystem value terms. DSF commissioned an assessment of a net present value for a 50-year period of $205 billion, for the Peace River watershed. However, the study did not separate out the part of the Peace Valley that would be affected by Site C.[48]

Site C would flood 6,469 hectares of Classes 1-7 land (including 3,816 hectares capable of cultivated use, i.e. Classes 1-5),[49] compared to 16,831 Class 1-3 agricultural land in the Peace River Valley as a whole,[50] and compared to 4.7 million hectares of agriculturally suitable land protected in BC's Agricultural Land Reserve.[51] The JRP found that this is not significant in the context of BC or western Canadian agriculture, although significant for the affected farmers.[52]

BCSEA recognizes that the large and localized impacts of Site C would represent a strong negative for those directly affected, particularly First Nations and landowners who would be expropriated.

I. First Nations rights

According to BC Hydro, "BC Hydro focused its consultation efforts on 29 Aboriginal groups, including Treaty 8 First Nations and Métis groups in British Columbia, Alberta and the Northwest Territories, as well as two non-treaty First Nations in BC."[53] First Nations rights in the area exist and would be affected by Site C. The affected First Nations must be suitably consulted and accommodated, as required by law. Should this not be achieved, BCSEA believes that Site C should not proceed.

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[45] *Report of the Joint Review Panel: Site C Clean Energy Project*, 2014, pages 313 & 314.
[46] *Ibid*, page 22.
[47] *Ibid*, pages 180 & 181.
[48] *The Peace Dividend*, Sarah J. Wilson, 2014, page 11. http://www.davidsuzuki.org/publications/DSF_Peace_natcap_web_July_29%20copy.pdf
[49] *Report of the Joint Review Panel: Site C Clean Energy Project*, 2014, p. 145.
[50] *BC's Peace River Valley and Climate Change*, Feinstein, 2010, p. 65 (citing Lion's Gate Consulting), page 40 http://www.ceaa.gc.ca/050/documents/p63919/98108E.pdf
[51] BC Agricultural Land Commission website: http://www.alc.gov.bc.ca/alc/content.page?id=B5D49B921F954C6C80F73292B90D797F
[52] *Report of the Joint Review Panel: Site C Clean Energy Project*, 2014, p. 316.
[53] *Ibid*, page 32.

Appendix 1. Solar PV

Solar panels gather light from the Sun and turn it into electricity, known as photovoltaic generation, or PV. Compared to hydropower generation and thermal generation from burning coal or gas it is a relatively new source of energy, but recent progress has been very rapid.

In 1956, solar modules cost $300 per watt. Today, producers in China are selling them at 50 cents a watt. Ray Kurzweil, the futurist, has theorized that solar PV could meet the world's entire electricity needs by 2031 if solar PV's exponential growth continues. The International Energy Agency, more realistically, estimates that solar PV could meet 16% of the world's electricity needs by 2050.

Germany has become renowned for its solar success. By November 2014, German homeowners, businesses, farms and utilities had installed 38 GW of solar PV, producing 31,000 GWh of electricity for the first ten months of 2014, 7.4% of Germany's electricity production, equivalent to about half of BC's annual electricity consumption.[54]

Germany's success is being driven by a policy instrument known as the Feed-In Tariff, designed to assist Germany's transition away from nuclear and fossil fuelled power. The tariff gives solar producers a guaranteed 20-year price high enough to make an investment attractive. As the cost of solar generation falls, the tariff is reduced. Ontario is using the same policy instrument to speed the phase-out of coal-fired power: an Ontario homeowner who installs solar on the roof receives 38.4 cents/kWh.

In 1980, the cost for installed solar, including labour, inverters and racking was $27 per watt. In 2013, First Solar expected its total installed cost to fall from around $1.59/w to below $1.00/w by 2017.[55] [56] Research by McKinsey & Company "suggests that as they become cheaper, the overall costs to consumers are poised to fall to $2.30 (per watt) by 2015 and to $1.60 by 2020."[57] In Austin, Texas, solar

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[54] *Electricity production from solar and wind in Germany in 2014*. Fraunhofer Institute. http://www.ise.fraunhofer.de/en/downloads-englisch/pdf-files-englisch/data-nivc-/electricity-production-from-solar-and-wind-in-germany-2014.pdf

[55] *Solar costs to halve as gas prices surge*. ReNew Economy, March 21, 2014. http://reneweconomy.com.au/2014/solar-costs-to-halve-as-gas-prices-surge-27907

[56] *U.S. Solar Is 59 Percent Cheaper Than We Thought It Would Be Back In 2010* Climate Progress, Oct 22, 2014. http://thinkprogress.org/climate/2014/10/22/3583232/solar-us-prices-lower/

[57] *The disruptive potential of solar power*. McKinsey & Company, April 2014.

power is being sold to Austin Energy for 5 cents/kWh (8 cents/kWh US without the federal tax credit).[58]

The US Department of Energy's SunShot Initiative aims to make solar energy cost-competitive with other forms of electricity by 2020. SunShot envisions a scenario in which installed utility-scale solar PV will cost US 6 cents/kWh without subsidy by 2020 ($1.00/watt, installed), based on least-cost geographic deployment. SunShot says that since its launch in 2011, the average cost per kWh of a utility-scale PV project has dropped from about US $0.21 to $0.11. [59]

The rapid fall in the cost of solar PV power is one reason why the BCSEA is recommending that BC Hydro include a fresh look at solar PV in a new Integrated Resource Plan. BCSEA's research leads it be believe that a call for power in BC could realistically expect to receive bids for cost effective utility scale solar PV.

Solar energy is generated primarily during the summer, while BC's peak power needs are in winter. The extent to which solar power generated over the summer and fall might enable BC Hydro to store more water behind its dams is one of the solar details that requires proper analysis.

[58] *Solar Less Than 5¢/kWh In Austin, Texas!* Clean Technica, March 13, 2014 http://cleantechnica.com/2014/03/13/solar-sold-less-5¢kWh-austin-texas
[59] SunShot: http://energy.gov/eere/sunshot/mission

Getting Close to Price Parity. The price of crystalline silicon photovoltaic cells has decreased exponentially over the past several decades as manufacturing capacity has ramped up.

Appendix 2. Wind

The first modern wind turbines were installed in Denmark in the 1980s. Since then, the global production of wind energy has soared, and prices have fallen.

Between 1980 and the early 2000s, reductions in capital cost and increases in performance reduced the levelized cost of onshore wind energy from over $150/MWh to approximately $50/MWh.

In 2013, the global cumulative installed wind capacity grew by 12.5%, reaching 318 GW. China leads with 91 GW, followed by the US (61 GW), Germany (34 GW), Spain (23 GW), India (20 GW) and Britain (10 GW). Canada increased its wind generating capacity during 2013 to 8.5 GW. Ontario leads with 2.4 GW. BC has 0.5 GW. The Global Wind Energy Council expects to see 47 GW of new installation in 2014.

The cost of wind power has been falling dramatically, based on technological advancement and the efficiencies that come with mass production. The average nameplate capacity of turbines has also been increasing, along with turbine height and rotor diameter. As a result of these changes, the annual energy production per square meter of swept rotor area has been showing annual improvements of 2%-3% for 15 years. Due to these improvements, the average capacity factor (output as a percentage of nameplate capacity) of wind projects has risen to 32%, with some projects in particularly windy areas showing 40%.

Wind power is an intermittent resource, which requires firming and grid integration. The larger the number and the geographical spread of turbines, the less the intermittency, since the wind is almost always blowing somewhere. Wind lends itself well to being a distributed resource. Like solar, its cost is at the front-end, with zero subsequent fuel costs, since the wind itself is free.

Sources:

IEA Wind Task 26: The Past and Future Cost of Wind Energy. NREL, 2012.
https://www.ieawind.org/index_page_postings/WP2_task26.pdf

Appendix 3. Demand-Side Management

Energy Efficiency and Conservation ('demand side management' or 'DSM') reduces the amount of energy that a utility's customer needs ('demands') to achieve their purposes. Hence, 'demand side management,' as distinct from 'supply side management,' which consists of acquiring and supplying more power to customers in response to increased demand.

DSM comes in various forms:

- efficiency (achieving a large proportion of useful energy from a given amount of fuel burned or electricity consumed),

- conservation (accomplishing the same objective by using less energy, such as avoiding the loss of energy, e.g. through increasing thermal insulation and reducing air leakage in a building's envelope, or needing less energy, e.g. by moving into a new house),
- load curtailment (agreed-on reductions in power supply, e.g. an industrial contract to suspend operations during times of peak load),
- demand reduction (reducing peak capacity requirements, e.g. by spreading industrial load over 24 hours instead of 8 hours), and
- peak shifting (changing the time energy is consumed to off-peak hours).

As well as reducing the amount of energy a utility must deliver, DSM reduces capacity requirements, i.e. the maximum amount of energy that the utility must deliver at times of peak demand. This is particularly true of 'capacity focused DSM,' such as load curtailment, demand reduction and peak shaving.

For homes, offices and commercial businesses, the main forms of DSM address energy use in buildings, particularly increasing the insulation in walls, roofs and basements; reducing air leakage; and improving the efficiency of energy use in space and water heating. Also important are installing efficient lighting; manually or automatically turning off unused lighting and equipment; and optimizing ventilation and temperature.

For industry, large energy savings can be achieved by installing more efficient motors and optimizing the efficiency of industrial processes.

Appendix 4. Geothermal electrical generation

Geothermal electricity production uses heat that exists under the Earth's surface. A geothermal generating facility has pipes within deep bore holes that can be two or more kilometres into the ground. Heat from the underground source powers an electrical turbine, by creating steam or by the use of a heat exchanger.

Geothermal power has many advantages. It is base-load power, which is firm and dispatchable. It is renewable. It requires no external fuel and has no ongoing fuel costs. It is reliable. It an almost zero-carbon source of electricity. It produces the same amount of electricity independently of season and weather.[60]

The main challenge with increasing the amount of geothermal electrical generation is that expensive exploration and drilling is required in order to locate optimal sites.

[60] *Contribution of Geothermal Energy to Climate Change Mitigation: the IPCC Renewable Energy Report*. World Geothermal Congress, 2010. http://www.geothermal-energy.org/pdf/IGAstandard/WGC/2010/0225.pdf

Globally, little more than 12 GW of geothermal capacity has been installed in 70 countries, led by the US, El Salvador, Kenya, the Philippines, Iceland and Costa Rica. However, installations are estimated to grow to 170 GW by 2050.[61]

Canada and many other countries have not developed their geothermal resources, primarily due to the cost and risk of exploratory test drilling.

The World Bank's *Global Geothermal Development Plan* states that validating the availability of commercially viable geothermal resources through test drilling can cost US$15-25 million per field, requiring at least 10% of the total capital expenditure to be spent up front, with no guarantee of return. It can take three years of test drilling to provide sufficient confidence for investors to proceed. As a result, commercial financing is often not available. In response, government financing has generally been the main means of supporting geothermal exploration. This can be in the form of government projects, cost-sharing with private parties, or in partnerships with private developers.[62]

For fiscal 2013, the US Congress assigned $38 million to the Department of Energy, which has set goals to develop tools to lower the upfront cost of exploration, and to try to reduce the levelized cost of newly developed geothermal systems to US$0.06/kWh by 2030.[63] In Europe, a target has been set to try to reduce geothermal generation costs to $0.029/kWh by 2030.

To address the up-front financial problem, the World Bank's Global Geothermal Development Plan is mobilizing US$500 million in concessional financing to develop a portfolio of test drilling projects, allowing the financial risk to be shared across a wide range of projects.

BC has known geothermal resources, but only limited test drilling has occurred, due mainly to the expense. BC Hydro has estimated that BC has 700 MW of firm geothermal potential. On November 25th 2014, the Canadian Geothermal Energy Association issued a report claiming that BC's geothermal resource is larger than BC Hydro's estimate. The Association states that an equivalent amount of power to Site C (5,100 GWh/year) could be developed for half the capital cost and at a lower levelized cost. CanGEA recommended placing a one-year moratorium on Site C to allow time for better technical analysis of BC's geothermal resources, and that

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[61] *Ibid.*
[62] *Global Geothermal Development Plan.* World Bank, 2013. http://www.esmap.org/node/3027
[63] *US National Academy of Sciences Geothermal Update*, November 2013. http://energy.gov/sites/prod/files/2014/02/f7/GTO-NAS.pdf

geothermal energy be referred to the BC Utilities Commission for review and recommendations by November 2015.[64]

On November 24th 2014, Geoscience BC, a government funded non-profit organization mandated to attract mineral and oil & gas investment to British Columbia, issued a Request for Proposals to deliver an assessment of the economic viability of geothermal energy in British Columbia for electrical power generation, to review sites previously studied and areas identified through for geothermal energy, and to complete a Geothermal Development Decision Matrix for each of 18 sites.[65]

Appendix 5. Energy Storage

Energy storage is a rapidly advancing field of research, with significant investments and regulatory effort being applied to develop storage resources that can help to stabilize the power grid, integrate intermittent energies onto the gird and reduce the need for excess generation capacity to meet peak loads. Storage is a new enough field that the relative costs of technologies have not been established.

Currently, the dominant form of grid storage is water storage in reservoirs behind dams with hydro-electric generating stations, which is what BC relies upon. Reservoir storage may be supplemented by 'pumped storage' capability, the ability to use surplus power in times of low load to recharge a reservoir, so that more generating capability will be available in times of high load.

However, reservoir storage is a geographically limited resource. Increasingly, utilities that don't have access to such storage are urgently searching for alternative ways to stabilize their loads without having to acquire large amounts of excess generating capacity.

Battery storage is a promising new technology. Other technologies include flywheel storage and thermal (ice) storage.

Here are some examples of current grid storage initiatives:

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[64] *Geothermal Energy: The Renewable and Cost Effective Alternative to Site C*. CanGEA. http://www.cangea.ca/uploads/3/0/9/7/30973335/cangea_geothermal_report_backgrounder_november_2014.pdf

[65] *GeoScience BC Geothermal RFP* http://www.geosciencebc.com/s/RequestsforProposals.asp?ReportID=685050&_Type=Request-for-Proposals&_Title=Economic-Viability-of-Geothermal-Resources-in-British-Columbia

- The Texas utility, Oncor, is proposing to invest $US 5.2 billion, hoping to acquire 5,000 MW of batteries.[66]
- The State of California has mandated that its utilities must procure 1,325 MW of new storage by 2024.[67]
- Southern California Edison's recent storage procurement call resulted in some 235 MW of battery power being contracted.[68]

[66] *Texas Utility Oncor Wants to Invest $5.2B in Storage: Can It Get Approval?*, Jeff St. John, November 2014, greentechgrid. http://www.greentechmedia.com/articles/read/Texas-Utility-Oncor-Faces-Opposition-on-Its-5.2B-Bet-on-Distributed-Energy

[67] *Will California's Energy Storage Procurement Process Unleash the Battery Market?*, Tam Hunt, November 2014, greentechgrid, http://www.greentechmedia.com/articles/read/Will-Californias-Energy-Storage-Procurement-Process-Unleash-the-Battery-Ma

[68] *Breaking: SCE Announces Winners of Energy Storage Contracts Worth 250 MW*, Eric Wesoff and Jeff St. John, November 2014, greentechgrid, http://www.greentechmedia.com/articles/read/breaking-sce-announces-winners-of-energy-storage-contracts