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please see the attachment. Comments relate to question #68, appendix C and expand on comments made previously.

FEASABILITY OF SITE C

Submission #2 : Site C and BC Hydro's estimates of renewables, specifically solar.

SUBMISSION TO BC UTILITIES COMMISSION INQUIRY on SITE C
by Thomas Mommsen, Ph.D.
[redacted]
on behalf of the Galiano Solar Coop
October 11, 2017

There are a number of aspects of an alternate scenario involving solar that have been addressed by BC Hydro in a disingenuous manner, disregarding current economic realities, the rate of technological development, real solar potential, and the carbon footprint of solar *vs* large scale hydro. In the following I will respond largely to the questions posed by the commission (Appendix C, #68), but also provide relevant data that counters BC Hydro's dismissal of solar.

<u>Costs</u>
In its original model, BC Hydro assumed a cost for solar to be around $3.60 /Watt, which is way out of line with reality. In fact, a bulk buy of 80 kW of tier-1 solar equipment for 14 residential arrays on Galiano Island in 2015, resulted in a (permitted and installed) cost of $3.29/W, with permitting accounting for close to 10% of the cost. Since then costs for complete residential arrays in BC have decreased by at least 20%. Therefore, even the BC Utilities Commission request of BC Hydro to rerun their model for a cost of $1.64/W in a scenario for 2017 seems a little on the high side, since utility installations in the US are around US$1.00/W already (NREL 2017), including soft costs and profit. Also, a reduction in the capital cost of solar by 60% by 2040 is likely an underestimate.

The most recent solar auction in the US yielded a winning bid of US$45/MWh, **including storage.** The days that hydroelectricity was cost-competitive are clearly over.

<u>Projected cost for a 5 MW utility solar installation</u>
In the absence of precedents for similar arrays in BC, one has to employ numbers from other jurisdictions. Using recent numbers from the NREL study, such an installation would cost around CA$ 6.9 million for a fixed tilt installation and CA$ 7.4 million for single-axis tilt array. O&M costs for utility solar are between 0.2% and 0.5% of installation costs, and thus about a fifth of the O&M costs for large hydroelectric installations.

Assuming a very conservative annual cost decrease of 5% (the reality has been close to 8%/y, although there is no reason to believe that the decrease will be linear), the cost for a 5 MW utility solar installation (fixed tilt) would be CA$ 4.58 million in F2025 and CA$ 2.74 million in F2035. Hydroelectricity, in contrast is a mature technology and price decreases over time are unlikely to be realized.

A number of other considerations will favour solar over hydroelectricity now and in the long term. Although all of these are highly relevant, it is difficult to attach exact dollar values to these considerations in the context of comparing a carbon emitting megaproject based on established technology with an emerging almost non-emitting technology that is evolving rapidly and has seen unprecedented decreases in costs.

1. Solar (5-40 kg CO_2e per MWh) has a much smaller carbon footprint than hydro (273 kg CO_2e per MWh); therefore, while solar PV contributes to large-scale decarbonization of electrical energy, hydro will be subject to carbon pricing in the range of $15.00 / MWh.
2. Solar represents distributed generation, where the above 5 MW would be ideal to supply small communities with all the power needed. Unfortunately, at this point, BC Hydro's rules in their Standing Offer Programme (SOP) and micro-SOP make it impossible for communities to establish community solar farms. The obstacles erected by BC Hydro which also includes a cap on all renewables amounting to 0.3% of BC Hydro's capacity per year, also explain the slow uptake of solar and its limited penetration in BC, even though BC is bathed in enough solar radiation to make solar a major contributor to our energy needs.
3. Distributed generation results in reduced line losses, since power is generated locally and transmitted over much shorter distances. Adding intermittent and distributed wind and solar to an energy mix will also increase the efficiency of transmission from any centralized generator.
4. Solar PV is a nimble, agile and scaleable technology, with very short timelines from concept to realization (less than two years for MW-scale installations) and absence of cost overruns due to short timelines Solar PV can provide quick ability to respond to potential overproduction, or local shortfalls in generation, without the commitment of large investments.
5. Although community solar would be ideal, somewhat larger, more centralized generation may have a place in a future energy scenario, but these will contribute less to energy security and have the same problems as any other centralized generator. The time has come to reconsider the utility of large, centralized generators - a business model that no longer applies.

<u>Solar radiation levels in BC</u>

Sunshine hours in BC (Vancouver: 1938 h/y; Victoria: 2109 h/y; Kamloops: 2080 h/y; Ft. St. John: 2095 h/y; Cranbrook: 2191 h/y; Dawson Creek 2213 h/y) do not reach the values in California (San Diego: 3055 h/y) or Arizona (Phoenix: 3872 h/y), but they are 25% higher than sites in Germany (Berlin: 1625 h/y; Frankfurt: 1586 h/y; Munich: 1709 h/y). However, since solar panels perform better at lower temperatures, the sunshine-hour advantage for California and Arizona is decreased substantially by the decreased effiencies in these areas where panels are working beyond their thermal optimum. In fact, a direct comparison between Abu Dhabi (3374 h/y) and Dawson Creek BC (2213 h/y), results in almost identical output by solar panels (within 10%) in these two places, once temperature compensation and non-production due to sandstorms (and subsequent clean-up) have been taken into consideration. Besides, in Dawson Creek, the albedo effect from reflection off snow cover should not be dismissed. In conclusion, large parts of BC are ideal for solar PV and it is difficult to identify true solar 'hotspots'. While coastal BC is already comparable to the best solar places in Germany, North-Eastern BC, Southern Vancouver Island, South-Eastern BC and many places in-between clearly stand out in solar PV potential.

It would be premature to make assumptions about utility scale solar capacity factor and life expectancy. Numbers for capacity factors are slowly entering the literature, but depend somewhat on the nature of the grid that they are integrated with, while the life expectancy of solar installations keep increasing as time goes by. Warranties on solar panels have now reached 25 to 30 years, while installations with the types of panels in current use have reached the 45 to 50 y mark and, although showing the expected light-induced decreases in efficiency (0.1% loss per y), they still produce power in the 80% range of nominal production.

Greenhouse Gas Emissions

It is somewhat disturbing to see the data presented by BC Hydro on greenhouse gas emissions for Site C, since in all tables presented, the entries are zero. As if moving millions of tonnes of material by trucks is devoid of carbon emissions, or the building of concrete diversion tunnels, or a concrete dam and generator housing is GHG free. As shown recently, the operation of any large hydroelectric dam generates substantial and long-term amounts of carbon dioxide and methane (Deemer et al. 2016; Scherer & Pfister, 2016; Harrison et al. 2017) in addition to the GHG emissions generated from biological material during the initial flooding phase of the reservoir.

I have spent the last four years researching solar - PV and CSP -, from theoretical, environmental, technological and practical angles, taking courses on microinverter technology, installation and operation and have been instrumental in bulk-purchase, installation and operation of 15 residential solar arrays on Galiano Island. I'd be more than happy to respond to any specific questions about solar PV.

References:

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NREL 2017: PV system cost benchmark summary (inflation adjusted 2010-2017); Figure ES-1

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