Good Afternoon Commission Secretary Patrick Wruck,

Please find attached our Phase 2 submission on Questions 46 and 47 from Peace Valley Landowner Association and Peace Valley Environment Association expert Robert McCullough.

Please let me know if there is any other information you require or any questions you may have.

Thank you for your assistance in this regard. I can be reached at [redacted]

Rob Botterell
In Questions 46 and 47 the Commission has asked British Columbia Hydro to model future reductions in wind and solar capital costs.

Actual wind and solar prices are vastly different than the British Columbia Hydro estimates. For example, British Columbia Hydro relies on a Hatch study that is several years out of date.¹ More recent data provides very different answers.

For example, I recently commented on a Burlington Northern freight train carrying components of a new wind farm along I-5. The components appear to have been destined for the new Skookumchuck Wind Energy project southeast of Olympia, Washington.

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¹ Project Cost Review Final Report, Hatch, Sura L. Murphy, May 19, 2015.
Press coverage indicates that the price for the power from this project is US$51/MWh.\textsuperscript{2} This compares rather favorably with the out of date estimates by British Columbia Hydro which range from C$104.77 to C$315.48/MWh.\textsuperscript{3}

Hatch has continued to issue similar studies. A significantly more recent study provides prices in the range of C$48.43 to C$69.82/MWh for a project in the Northwest Territories.\textsuperscript{4}

A variety of industry sources provide a much more favorable picture of wind and solar cost declines than that assumed by British Columbia Hydro. The following two charts have been taken from the most recent Lazard study on the Levelized Cost of Energy (LCOE) generation.\textsuperscript{5} The complete document has been appended to this submission since it is a very useful unbiased source.

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\textsuperscript{2} Wind power will fuel light-rail trains, Seattle Times, Mike Lindblom, April 19, 2017.

\textsuperscript{3} British Columbia Hydro and Power Authority – British Columbia Utilities Commission Inquiry Respecting Site C – Project No. 1598922 – Preliminary Report, Figure 15, page 12, Appendix A.


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Lazard Estimates of the Levelized Cost of Solar from 2009 to 2016
2016 Canadian Dollars/MWh

Figure 3: LCOE of solar generation from 2009-2016.

Not only are the rates of decline in cost remarkable, the absolute levels reported by Lazard are declining below traditional fossil fuel generation.

A number of studies point to additional future reductions. One very authoritative study was issued by the International Energy Agency last year. The IEA bases its quantitative figures on the mean response of over one hundred industry experts, and nearly all agree that wind costs will decrease significantly over time from current levels.

According to the report, the LCOE of onshore wind energy is expected to continue falling until at least 2050. While offshore turbines will become practical sources of energy in the medium-term, onshore wind is currently competitive with all major sources of energy generation.

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The IEA expects that most of these cost reductions will come about as a result of wind turbines operating for longer, being more efficient at generating power, and a lower cost of production and operation. The table below summarizes the IEA’s estimate of the percent change of certain statistics of onshore wind from 2014 to 2030:

<table>
<thead>
<tr>
<th>Specification</th>
<th>% change by 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity Factor</td>
<td>+10%</td>
</tr>
<tr>
<td>Project Life</td>
<td>+10%</td>
</tr>
<tr>
<td>CapEx</td>
<td>-12%</td>
</tr>
<tr>
<td>OpEx</td>
<td>-9%</td>
</tr>
</tbody>
</table>

Table 1: IEA’s predicted change in key wind project statistics/specifications.

Except in the most pessimistic scenario, this technological improvement will result in a dramatic reduction in the LCOE for producing wind power.
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The LCOE of wind is already competitive with nearly all sources of convention electrical generation, and the experts that spoke with the IEA predicted that a number of innovations will gradually reduce the price of generation. Most of these innovations, summarized below, are not the fanciful dreams of science fiction writers, but easily attained with this and the next decade’s technology.

Figure 5: IEA’s predicted percent change in cost of onshore wind projects 2014-2050.8

Figure 6: Predicted cost-saving innovations in onshore wind generation.9

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8 Ibid., page 11.
9 Ibid pg. 30
The table below summarizes the predicted change in the LCOE of wind energy according to various sources. While BC Hydro forecasts no reduction, other authoritative agencies forecast a reduction of between 10% and 17% over the planning period.

<table>
<thead>
<tr>
<th>Source</th>
<th>2017 C$/MWh</th>
<th>2020 % change in costs</th>
<th>2025 % change in costs</th>
<th>2030 % change in costs</th>
<th>2035 % change in costs</th>
<th>2040 % change in costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCH¹⁰</td>
<td>C$104.77-11 C$315.48¹¹</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Deloitte</td>
<td>-</td>
<td>-</td>
<td>-10-12%¹²</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lazard</td>
<td>C$69.04¹³</td>
<td>-</td>
<td>-</td>
<td>-12%¹⁴</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>IEA</td>
<td>C$76.97¹⁴</td>
<td>-</td>
<td>-</td>
<td>-12%¹⁵</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EIA</td>
<td>C$72.13¹⁶</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-17%¹⁷</td>
</tr>
</tbody>
</table>

Overall, British Columbia Hydro’s current estimates are high – very high – compared with industry estimates and actual wind farms operating nearby in Washington State. Industry expectations indicate a continued decline in costs – even after the rapid declines in recent years.

¹⁰ BC Hydro BCUC Inquiry Submission appendix L.
¹¹ British Columbia Hydro references the “Unit cost of Energy.” This is “very similar” to LCOE, but the definition of UEC is still unclear.
¹² Deloitte doesn’t provide a LCOE, but their predicted capital and operating costs for wind are well below BC Hydro’s.
¹⁵ Ibid. pg. 64
¹⁷ Ibid. Pages. 14-17
Another way to display the wide gap between British Columbia Hydro’s estimates and those used elsewhere in the industry is to compare the capital costs in dollars per kilowatt:

<table>
<thead>
<tr>
<th>Source</th>
<th>2017</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCH</td>
<td>C$2339 -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C$2630\textsuperscript{18}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deloitte</td>
<td>C$1,600 -</td>
<td>-10%</td>
<td>-25%</td>
<td>-30%</td>
<td>-40%</td>
<td>-45%</td>
</tr>
<tr>
<td></td>
<td>C$3,200\textsuperscript{19}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lazard</td>
<td>C$1,500 -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C$2,040\textsuperscript{20}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEA</td>
<td>C$~2250\textsuperscript{21}</td>
<td>-10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCH - Solar</td>
<td>C$1690\textsuperscript{22}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-60%</td>
</tr>
</tbody>
</table>

Overall, British Columbia Hydro’s current estimates are high – very high – compared with industry estimates and actual wind farms operating nearby in Washington State. Industry expectations indicate a continued decline in costs – even after the rapid declines in recent years.

\textsuperscript{18} BC Hydro Wind Project Cost Review. May 2015, Pages 22-25