McCULLOUGH RESEARCH

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PRINCIPAL

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To: British Columbia Utilities Commission

From: Robert McCullough
Eric Shierman
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Subject: Question 22: Export Sales

British Columbia is a member of the Northwest Power Pool, the utility organization that comprises the four northwestern U.S. states and the two southwestern Canadian provinces. The NWPP is a component of the Western Electricity Coordinating Council that acts as the reliability coordinator for western U.S. and Canadian utilities.

The most important trading location on the west coast is the Mid-Columbia hub. Unlike the two trading hubs in California, it is an open outcry market with no restrictions on transparency. Entry and exit is free – there are no arbitrary restrictions as those that characterize the California hubs.

As with all open outcry markets, prices are determined freely between market participants. While prices converge through normal market processes, Mid-Columbia has many more products than administered markets. This makes reporting prices a bit challenging. The solution at Mid-C is the same as that in other open outcry markets – a third party accumulates transaction data and generates a price index. Since the mid-1990s, the primary index was generated by Dow-Jones. Several years ago, the Mid-C index was sold to Platt's.

The Mid-C index is frequently used for settlement purposes by the major marketplaces – the Intercontinental Exchange and the Chicago Mercantile Exchange. These marketplaces provide a wide variety of derivatives, including forward markets.

In the U.S. all physical transactions are public (with minor exceptions for small participants). The transactions are filed with the Federal Energy Regulatory Commission. Access to the database is open at https://eqrreportviewer.ferc.gov/. Individual plant operational data is generally available at the monthly level from the U.S. Energy Information

Administration. Operations on an hourly basis are available from the Environmental Protection Agency. In the Pacific Northwest, hydro operations are generally available by the specific utilities – most significantly the Bonneville Power Administration.

In addressing the detailed questions, we have adopted the naming convention of assigning numbers to the major bullets and letters to the minor bullets.

22.1 Please provide a breakdown BC Hydro's market price forecast for F2025 (US $36/MWh) and F2034 (US $46/MWh) showing (in Can $ and US $): Mid C price; wheeling costs; real power losses; other (please describe).

We cannot answer questions concerning British Columbia's market forecast since details have not been made public. We can observe that it is a relatively poor forecast since it diverges from actual market prices.

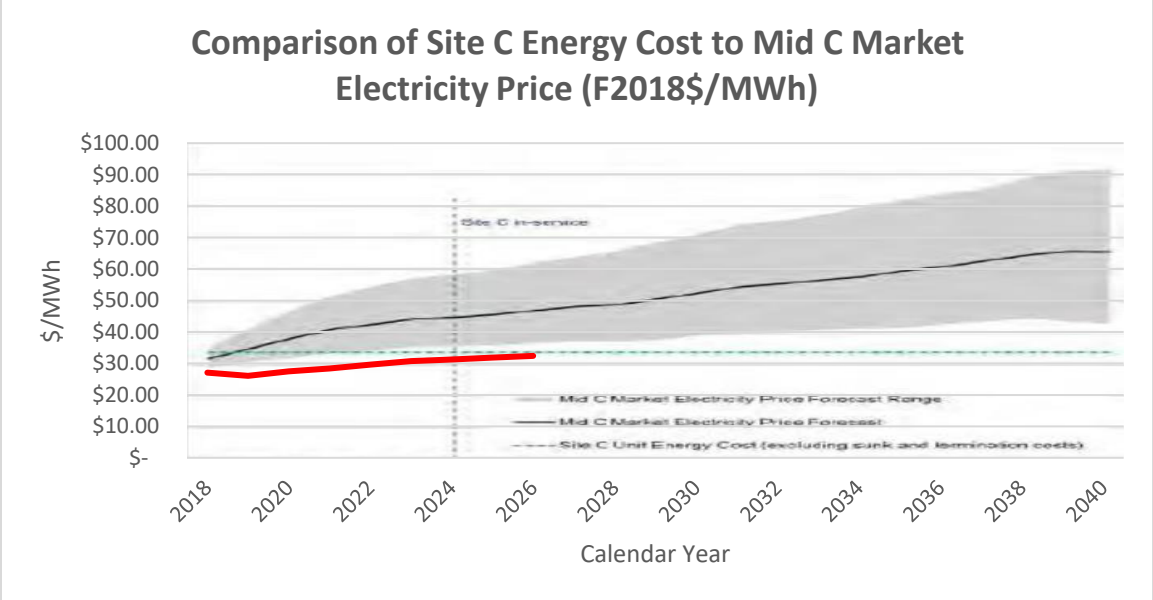

Figure 1: BCH's forecasted mid-c price and ICE forward price

The red line represents forward prices taken from the ICE MDC (on-peak) and OMC (off-peak) markets on September 22, 2017.

The differential between the LCOE of Site C and the forward Mid-C price is considerable. In 2024, for example, selling the output at September 22nd prices on the Intercontinental Exchange would lead to a significant loss:

($C31.25-C$105) x 5,100 GWh =- C$376.1 million[1]

22.1(a) Please explain whether (i) the market price forecast assumes the Mid C price is set by a CCGT; (ii) whether Mid C prices over the past 5 years support this assumption, and (iii) to what extent lower price renewables may increasingly set the Mid C price at lower levels in the future.

Since the British Columbia Hydro forecast is undocumented, the answer to whether the forecast is set by the assumed price of a combined cycle generating turbine is impossible to answer. The remaining answers are quite simple to answer, however. Even the most modern combined cycle units in the Pacific Northwest operate at relatively low levels. The primary reason for this is that Mid-C prices are generally lower than the operating cost of the unit. For example, a modern CCGT like Port Westward, built in 2007, has a capacity factor of only 56% in 2016.[2]

Wind and solar have zero marginal cost (in some cases the marginal cost is even lower than zero since tax incentives depend on actual operations). This means that the lowest portion of the demand curve moves higher priced coal and natural gas units rightwards. The natural outcome is for increasing levels of renewables to lower the market price of electricity.

Question 22.2 Please provide, in graph and table form, the average annual Mid C price (on-peak, off-peak and all hours) for the last 20 years.

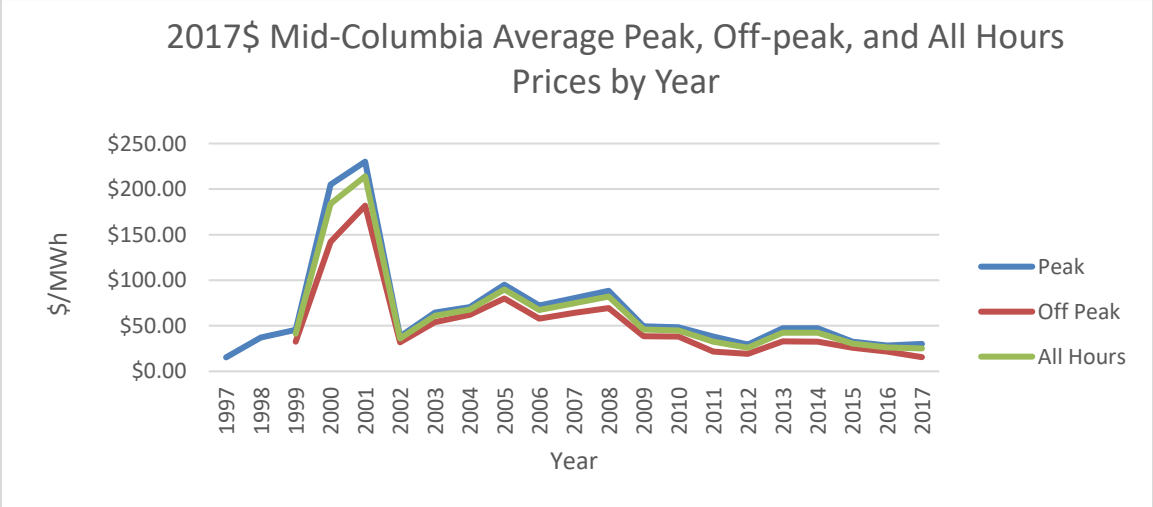

Figure 2: Average mid-c price by year 1997-2017

[1] McCullough Research. Costs of Continuing Site C and the Alternatives. August 30, 2017. Page 7.
[2] Electricity Information Administration. Electric power monthly. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_a. Accessed September 26, 2017

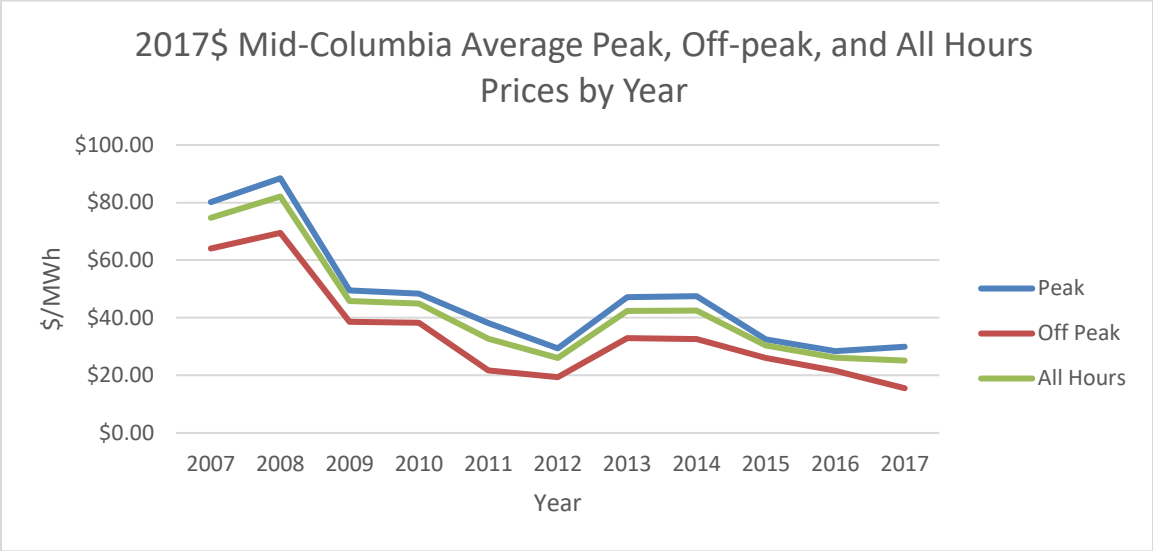

Figure 3: Average mid-c price by year 2007-2017

Year	Peak Price ($/MWh)	Off-Peak Price	All Hours Average
1997	$15.33	-	-
1998	$37.18	-	-
1999	$45.45	$32.65	$41.18
2000	$204.92	$142.19	$184.01
2001	$230.12	$181.85	$214.03
2002	$38.14	$31.75	$36.01
2003	$64.37	$53.91	$60.88
2004	$70.60	$62.01	$67.74
2005	$95.01	$79.89	$89.96
2006	$72.18	$57.92	$67.43
2007	$80.14	$64.00	$74.76
2008	$88.44	$69.48	$82.12
2009	$49.49	$38.62	$45.87
2010	$48.36	$38.24	$44.98
2011	$38.15	$21.68	$32.66
2012	$29.38	$19.33	$26.03
2013	$47.14	$32.98	$42.42
2014	$47.46	$32.59	$42.51
2015	$32.52	$25.99	$30.35
2016	$28.41	$21.57	$26.13
2017	$29.94	$15.53	$25.14

[3]

[3] Platts Daily Market Report. 1997-2017.

Note: Platts does not provide the Mid-Columbia off-peak price prior to 1999

22.3 Please provide in graph and table form, for each year from F2013 to F2017, a comparison of (i) the average all hours Mid C price for that year and (ii) the $/MWh price that BC Hydro received (after transaction costs, such as wheeling and power losses) for the sale of its surplus energy.

The electronic quarterly reports (EQRs) available from the United States Federal Energy Regulatory Commission (FERC) describe all major electricity transactions that take place in the United States. British Columbia Hydro sells electricity in the United States under the trade name Powerex. Powerex sale prices closely track the Platt's Mid-C index.

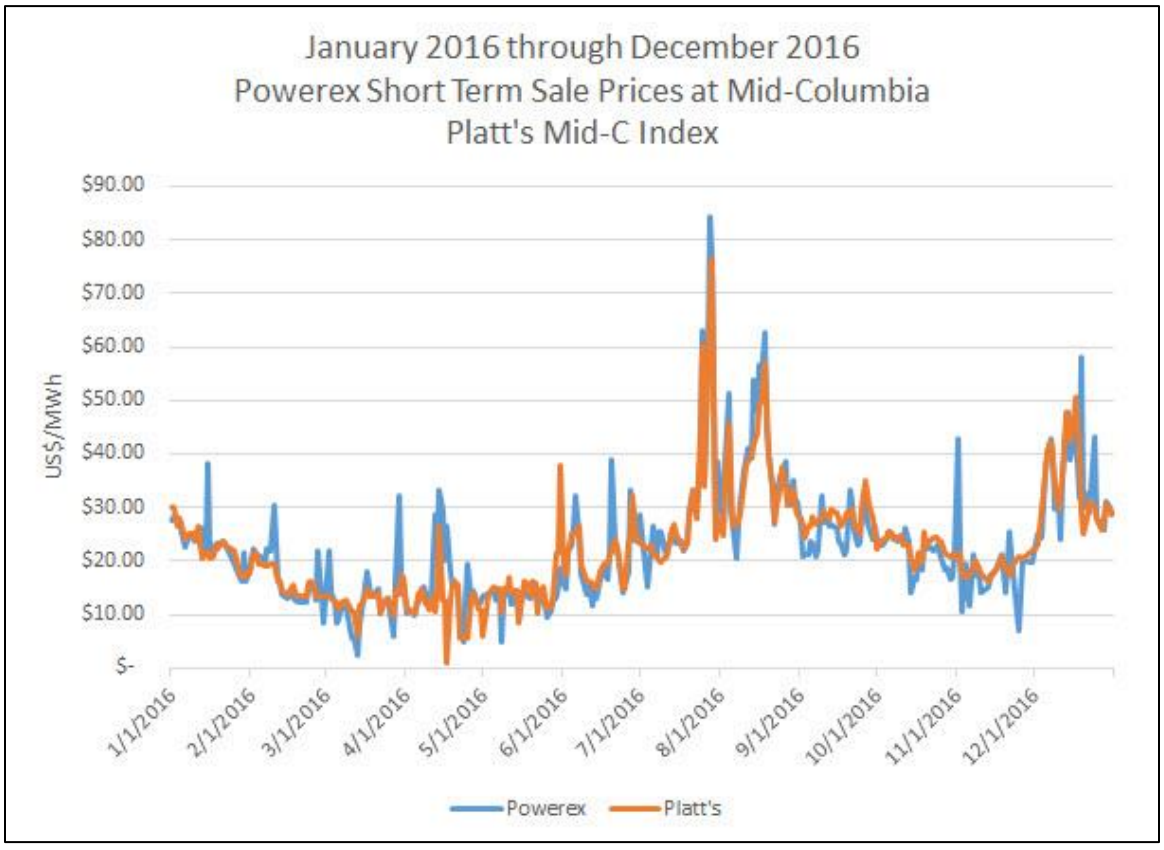

Figure 4: Comparison of mid-c price and price of power sold by Powerex (a BCH subsidiary)

The differential between Powerex short term energy transactions and the Platt's index at Mid-C (adjusted by product) is only US$.20/MWh.

22.4 Please provide, in graph and table form, for each year from F2015 to F2017, the monthly all hours, on peak and off-peak Mid C price.

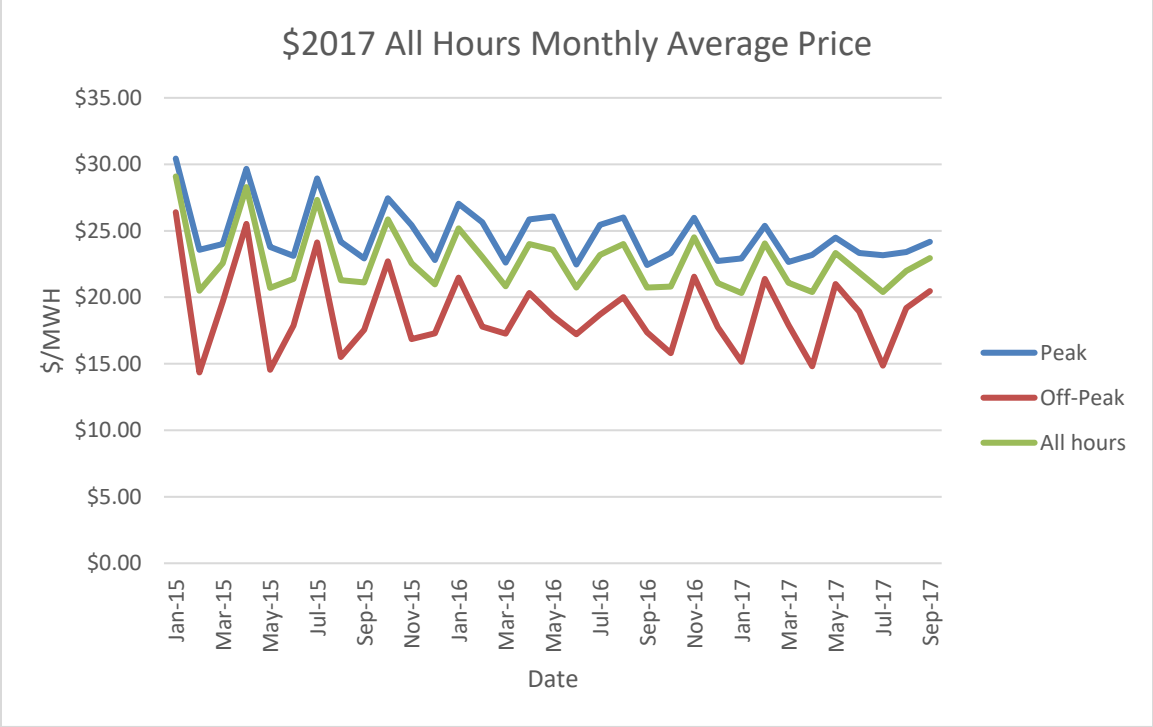

Figure 5: Average mid-c price by month 2015-2017

Date	Peak ($/MWh)	Off-Peak ($/MWh)	All hours ($/MWh)
Jan-15	$30.43	$26.40	$29.09
Feb-15	$23.57	$14.35	$20.50
Mar-15	$24.00	$19.68	$22.56
Apr-15	$29.65	$25.53	$28.28
May-15	$23.79	$14.54	$20.71
Jun-15	$23.13	$17.87	$21.38
Jul-15	$28.94	$24.12	$27.33
Aug-15	$24.17	$15.51	$21.28
Sep-15	$22.91	$17.57	$21.13
Oct-15	$27.45	$22.70	$25.87
Nov-15	$25.43	$16.86	$22.57
Dec-15	$22.81	$17.29	$20.97
Jan-16	$27.04	$21.48	$25.19

Feb-16	$25.65	$17.81	$23.04
Mar-16	$22.60	$17.26	$20.82
Apr-16	$25.86	$20.32	$24.02
May-16	$26.07	$18.59	$23.58
Jun-16	$22.47	$17.23	$20.72
Jul-16	$25.45	$18.70	$23.20
Aug-16	$26.01	$20.01	$24.01
Sep-16	$22.43	$17.36	$20.74
Oct-16	$23.32	$15.79	$20.81
Nov-16	$25.99	$21.54	$24.51
Dec-16	$22.74	$17.76	$21.08
Jan-17	$22.91	$15.14	$20.32
Feb-17	$25.38	$21.39	$24.05
Mar-17	$22.67	$17.92	$21.09
Apr-17	$23.20	$14.81	$20.40
May-17	$24.49	$21.00	$23.33
Jun-17	$23.33	$18.93	$21.86
Jul-17	$23.15	$14.86	$20.39
Aug-17	$23.40	$19.19	$21.99
Sep-17	$24.18	$20.46	$22.94

22.5 Please describe the energy and capacity markets in the US and Alberta that BC Hydro considers it will be able to participate in.

The United States represents the vast majority of British Columbia Hydro's export market, and the market price for electricity has undergone a steady decline for nearly a decade. As more renewable sources come online in the American Northwest, we expect these prices to decline even more. British Columbia Hydro will be hard pressed to make a profit selling electricity from large capital projects like the Site-C dam. In fact, from July 2016 to July 2017, the nominal value of BC's electricity exports to the United States fell by 21.1% (falling from $72,000,000 to $57,000,000).[4]

[4] Government of British Columbia. Trade Data and Statistics. B.C. exports with selected destination and commodity detail (XLS). http://www2.gov.bc.ca/gov/content/data/statistics/business-industry-trade/trade/trade-data. Accessed September 26, 2017

In 2016, Powerex only reported one capacity transaction at Mid-Columbia and that for a de minimus price.[5]

We can't say as much about energy markets in Alberta, but exports to Alberta are negligible compared to the international trade in electricity. British Columbia exported 13,555,281 MWh of electricity to the United States in 2016, but only 753,995 MWh to other Canadian Provinces in the same time period.[6] Even if the market in Alberta is extremely favorable for export, there are limited transactions flowing between the provinces. A significant shift in the status quo would have to take place in order for interprovincial trade to become comparable to trade with the United States.

22.5(a) Please describe any key difficulties BC Hydro might face in participating in the US and Alberta market, such as access to transmission and regulatory approvals required.

To transmit power to Alberta at a scale comparable to the international electricity trade would require a massive infrastructure investment since there is limited transmission capacity to the east from British Columbia – 800 megawatts. Even if the transmission was upgraded, the Alberta market is significantly smaller than the Pacific Northwest states of the U.S. Given that the GDP of Oregon and Washington is $820 billion and the GDP of Alberta is $330 billion,

[5] Powerex EQR filings at the U.S. Federal Energy Regulatory Commission. Accessed September 24, 2017.

[6] Government of British Columbia. Trade Data and Statistics. Electricity Exports and Imports (quantities) (XLSX). http://www2.gov.bc.ca/gov/content/data/statistics/business-industry-trade/trade/trade-data. Accessed September 26, 2017

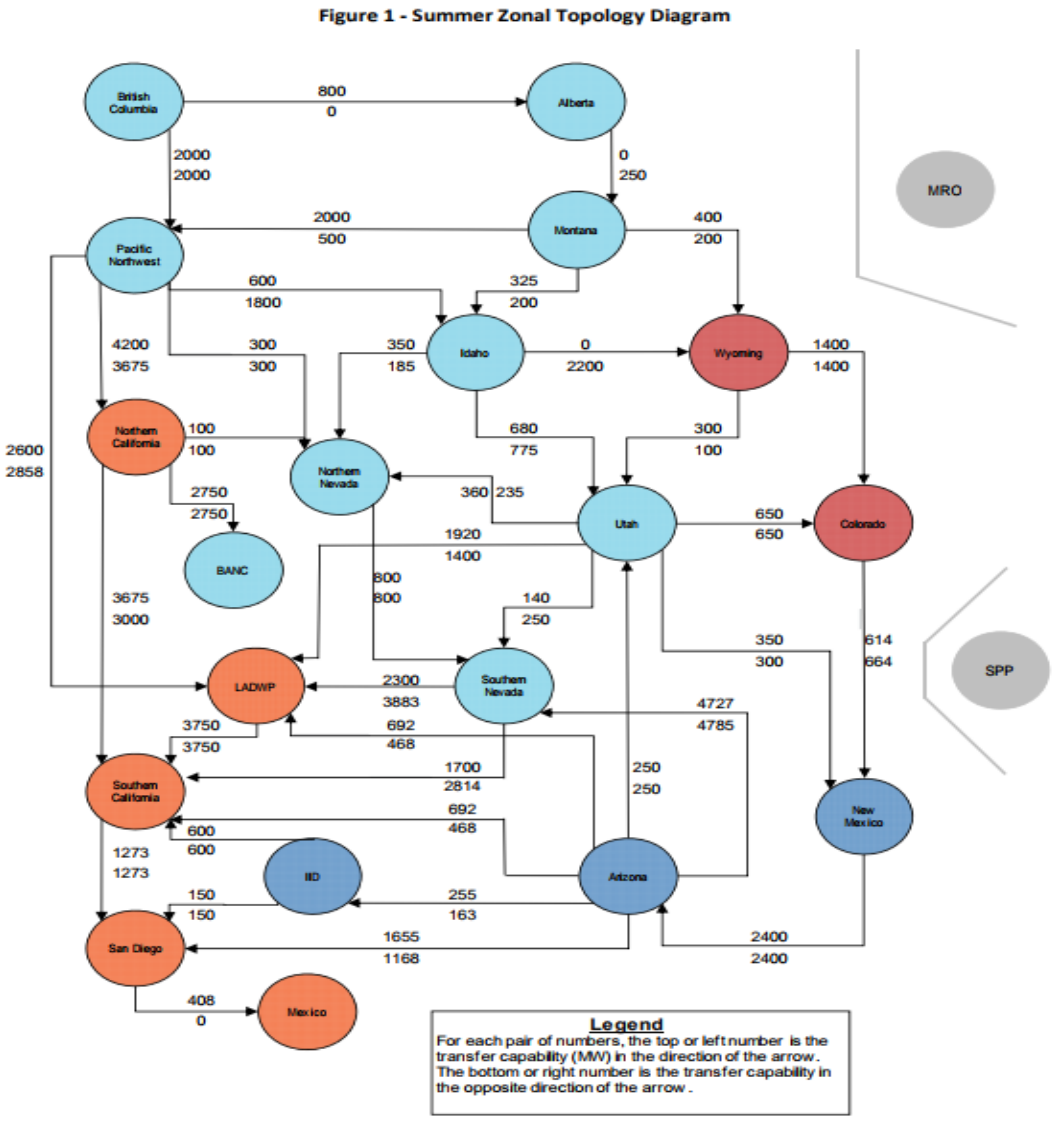

Figure 6: High voltage Transmission lines in Canada and the United States.[7]

Overall, the level of surplus in the Northwest Power Pool makes the U.S. a less than optimistic situation. The NWPP utilities enjoy a very favorable reserve margin:

[7] WECC, "2016 Power Supply Assessment," December 2016, page 19.

NWPP: Case 1 - Existing/Class 1 Resources Winter	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Net Internal Demand	71,071	71,945	72,844	73,504	74,122	75,069	75,722	76,308	76,994	77,374
Anticipated Internal Capacity	88,752	89,866	90,412	90,470	90,753	91,065	91,475	91,471	90,634	90,575
Wind Expected On-Peak MW	3,006	3,515	3,865	3,867	3,869	3,870	3,872	3,881	3,882	3,884
Percentage of Capacity	21.5%	23.4%	22.5%	22.5%	22.5%	22.5%	22.5%	22.4%	22.4%	22.4%
Solar Expected On-Peak MW	0	0	0	0	0	0	0	0	0	0
Percentage of Capacity	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hydro Expected On-Peak MW	34,358	34,379	34,400	34,488	34,382	34,386	34,392	35,385	35,838	35,841
Percentage of Capacity	65.1%	64.8%	64.6%	64.7%	64.5%	64.4%	64.4%	64.9%	65.1%	65.1%
Imports	6,760	6,700	6,800	6,766	7,517	8,188	8,598	8,694	8,966	9,419
Exports	1,700	0	0	0	0	0	0	100	993	1,161
Anticipated Resource Reserve Margin MW	5,812	5,906	5,403	4,690	4,252	3,459	3,107	2,419	782	279
Anticipated Resource Reserve Margin %	24.9%	24.9%	24.1%	23.1%	22.4%	21.3%	20.8%	19.9%	17.7%	17.1%

Figure 2: 2017 NWPP Winter Reserve Margins[8]

22.10 Please discuss the potential implications and impact of Powerex joining, or potentially not joining, the Energy Imbalance Market and how that relates to the value of Site C energy and capacity. Include an analysis and discussion of the potential impact resulting from an expansion of Energy Imbalance Market.

As a general rule, efficient shaping transactions are best implemented by contract rather than auction. The Northwest Power Pool has a long and extensive relationship in such transactions.

The "one size fits all" approach at the California Independent System Operator eliminates operational efficiencies that cannot be captured in real time – a central feature of isoperimentric (time and volume constrained) transactions. As a utility with a strong position in shaping services, they will find that their revenues will be maximized by selling specific solutions rather than dedicating valuable resources to a low end real time market. Although the comparison is not totally exact, using your Rolls Royce as an Uber hourly rental is not the highest and best use of the asset.

[8] Ibid, page 12.