100% Clean Energy Standard Discussion Paper

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Executive Summary

The Province of British Columbia (the Province) is undertaking an ambitious transition towards a low-carbon economy. The steps needed to meet the Province's environmental policy goals will range from extensive energy efficiency investments to large-scale electrification in the transportation and buildings sectors. Underpinning these and almost all other plausible pathways to deep decarbonization in British Columbia is electricity that is both clean and affordable.

The British Columbia Hydro and Power Authority (BC Hydro) has a long history of providing clean and affordable electricity to its customers. BC Hydro is endowed with a unique hydroelectric resource that has provided substantial benefits over the decades through its provision of low-cost clean power. The Province's electricity grid is part of a Western interconnected system that spans from Northern B.C. and Alberta to Baja California and El Paso, Texas. BC Hydro's system is unique in the West because it is capable of both producing and storing large amounts of clean electricity. The BC Hydro system typically has a significant quantity of surplus energy that can be exported to neighboring jurisdictions across the West.

Powerex Corp. (Powerex) is the exclusive marketer of the surplus power and surplus capabilities of the BC Hydro system as well as the Province's Canadian Entitlement supply (provided by the United States under the Columbia River Treaty), and works to ensure that British Columbia's surplus hydro supply is put to its highest and best uses. Powerex is a leading provider of clean electricity throughout the West, producing economic and environmental benefits for British Columbia and for its customers across the broader Western region. Current and potential future benefits associated with Powerex's wholesale electricity trading and marketing activity include:

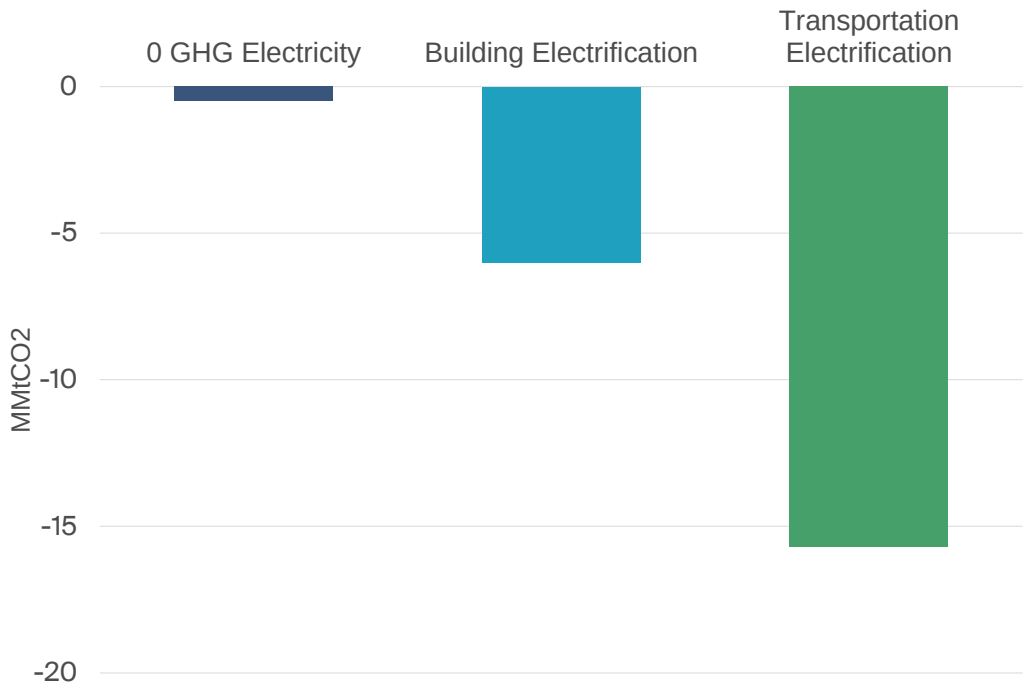
Cost Savings

- **Lower Electricity Costs for BC Hydro Customers –** All revenue from Powerex's surplus power sales and all net income go back to BC Hydro in its efforts to help reduce electricity rates for BC Hydro customers.
- **Lower Electricity Costs for Western Electricity Consumers –** Powerex, through its trade activities, provides grid services such as balancing and battery-like services that help reduce fuel costs as well as the cost of integrating renewables like wind and solar across the western interconnection.

Environmental Benefits

- **Deeper emissions reductions within B.C. from electrification, enabled by affordable electricity rates** – Powerex's activities help keep electricity rates affordable in B.C., which supports the adoption of technologies like electric vehicles and electric heat pumps that are key to reducing greenhouse gas (GHG) emissions in other sectors. Within British Columbia, the emissions reductions available from those measures far exceed the remaining direct emissions in the Province's electricity sector (Figure 1).
- **Reduced GHG emissions outside B.C. –** Powerex sells excess clean power to Alberta and to locations across the Western U.S., displacing the use of fossil fuel power plants and associated emissions *outside* of B.C. These power sales increasingly coincide with high fossil fuel and low renewable production, helping neighboring jurisdictions achieve their own carbon reduction goals.

Figure 1: B.C. Direct Electricity Emissions Reduction Opportunity vs Electrification Driven Opportunities



Note: this figure compares the emissions reductions available from complete decarbonization of electricity in British Columbia to emissions reductions from a 90% reduction in emissions from buildings and light-duty vehicles and a 50% reduction in emissions from heavy-duty vehicles compared to 1990 levels. Emissions figures are from the British Columbia *Provincial Greenhouse Gas Emissions Inventory*.

A combination of changing customer preferences and a wave of recent provincial, state and municipal policy actions have set the western grid on a course toward deep emissions reductions. Powerex and the BC Hydro system will play an important role in facilitating this transition both domestically and in neighboring jurisdictions. In order to enhance the environmental and economic benefits afforded by B.C.'s unique role as a provider of clean electricity solutions to the West, Powerex suggests the Province explore incremental changes to electricity sector policy and practices. These include:

1. ***Consider a BC Hydro commitment to serve 100% of its annual demand with clean energy (100% clean energy standard)*** – British Columbia currently requires at least 93% of electricity generation to be produced by clean or renewable energy resources within B.C.[1] However, over just the past year four Western states have committed to meeting 100% of their loads with clean electricity by mid-century. Others are likely to follow. Building on the Province's hydropower base, B.C. may be able to achieve such a standard much sooner than any other jurisdictions in the West. This would position the Province as a clear regional leader. In addition, the commitment would secure the Province's competitive position when offering its surplus hydro capabilities to customers in these external jurisdictions.

2. ***Seek alignment on treatment of electricity in regional GHG pricing programs*** – B.C. and California have both implemented GHG pricing mechanisms, but they take different forms and do not include mechanisms that allow for mutual recognition and reciprocity. Efforts to align B.C.'s and California's GHG pricing systems would be an important step toward establishing a broader

[1] B.C. Clean Energy Act Part 1, Objective 2(c).

regional GHG pricing framework as additional states adopt carbon-pricing policies. Such a framework would provide benefits throughout the West by removing trade inefficiencies and further enabling low-cost emissions reductions.

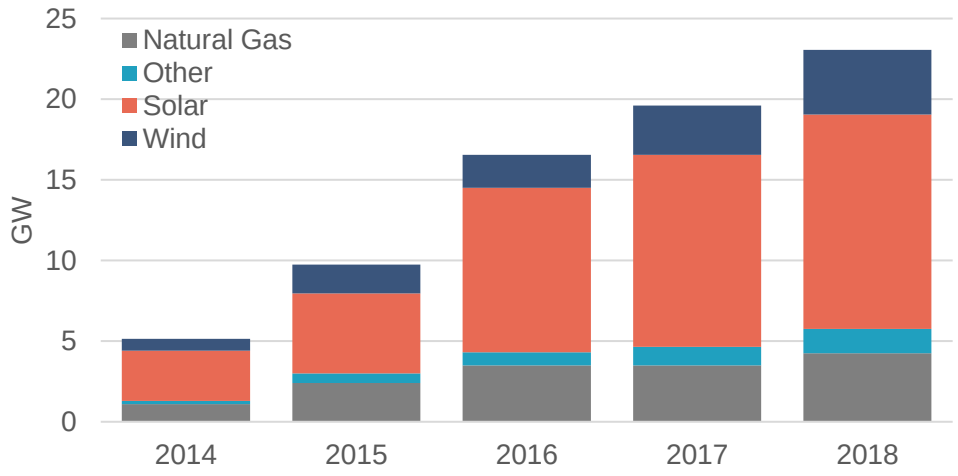
3. ***Consider the benefits of a regional perspective in provincial electricity sector policies and resource planning decisions related to the BC Hydro system*** – B.C. has a unique and important role in the interconnected Western electricity system, with substantial and growing opportunities available through electricity trade with neighboring regions. The Province's electricity sector policies and subsequent BC Hydro resource planning decisions should be mindful of this role and incorporate a regional perspective along with local considerations. In practice, this means considering how future policy and planning decisions may affect the ability of the BC Hydro system to support Powerex's sales of energy and battery-like services to its customers throughout the West. Providing those services furthers the Province's dual goals of ensuring affordable electricity for BC Hydro's ratepayers and achieving deep GHG emissions reductions.

I. Strong environmental policies in B.C. and across the West have reshaped the western power grid.

Over the past decade, British Columbia has established itself as a regional leader on environmental policy. In addition to B.C.'s 93% zero-carbon electricity supply requirement under the Clean Energy Act (CEA), the Province is also pursuing broader economy-wide decarbonization through initiatives designed to reduce emissions in the transportation, building and industrial sectors. B.C.'s carbon tax is among the most stringent economy-wide carbon pricing programs in North America.

B.C. is not alone in its commitment to achieving deep decarbonization. Other western jurisdictions are also taking steps to reduce their emissions. The most transformational energy system changes currently underway across the West are occurring in the electricity sector. A combination of policy initiatives, such as Renewable Portfolio Standards (RPS), and declining costs of renewable resource development have markedly expanded the amount of renewable energy that has been deployed throughout the West.

Figure 2: Western United States Cumulative Capacity Additions Since 2014

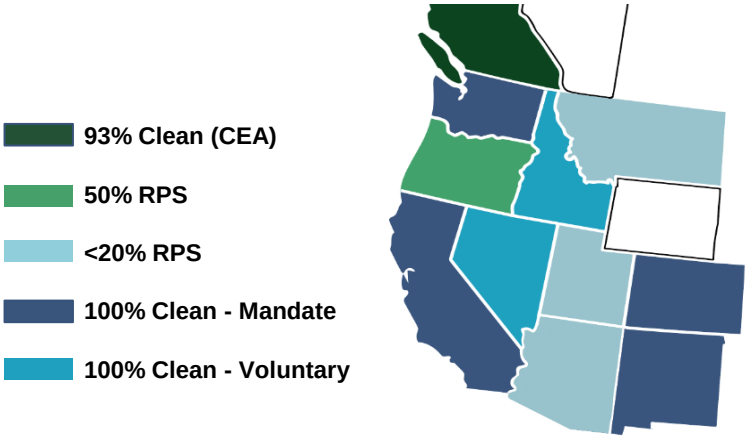


Note: data for this figure are taken from the U.S. Energy Information Administration *Preliminary Monthly Electric Generator Inventory*

The pace of the West's electricity sector transformation is likely to accelerate. Within the past year, four Western states (California, Colorado, New Mexico and Washington) have adopted policies that require their electricity demands to be met with 100% zero-emissions generation by mid-century or sooner. These state laws have been supplemented by utility commitments in Idaho, Oregon and Nevada to achieve similar targets.

In parallel, several jurisdictions within the Western region have, like B.C., adopted policies aimed at achieving economy wide GHG reductions. These economy-wide initiatives include many different policy approaches ranging from GHG pricing (e.g. cap-and-trade) to technology mandates (e.g. zero emission vehicle mandates and incentive programs).

Figure 3: Western Electricity Clean Energy Commitments



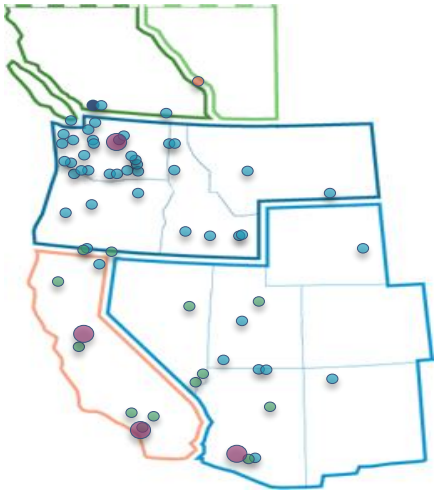
Note: The shade of each color indicates more and less stringent policy commitments. BC has Clean Energy Act (CEA) requirements for 93% clean or renewable generation (generation standard).

II. Powerex navigates evolving market opportunities to the benefit of B.C. consumers.

The Western electric grid is an interconnected system from both an engineering and economic perspective. Utilities and market participants across the West exchange power on timescales ranging from minutes to years. This wholesale electricity trading activity has always been an important feature of the Western electricity system but is becoming even more vital in the context of increasing deployment of variable energy resources like wind and solar.

Powerex sells wholesale electricity delivered from the BC Hydro system, as well as from its external portfolio of supply contracts, to Alberta and to a variety of customers located throughout the Western U.S. In doing so, Powerex has established a broad regional presence, with transactions spanning over 80 locations across the West. These transactions are enabled by Powerex's substantial investments in regional electricity transmission service, facilitating the delivery of energy products and related services when and where they are of highest value. Powerex's largest regional trading partner is California, followed by the Pacific Northwest, Alberta and the Desert Southwest.

Figure 4: Powerex transacts at more than 80 distinct locations throughout the West



Note: Powerex transacts at more than 80 distinct locations throughout the West; the largest trade is most typically with California. In 2018 Powerex executed 127,000 separate physical deliveries and used 2,125 distinct transmission paths.

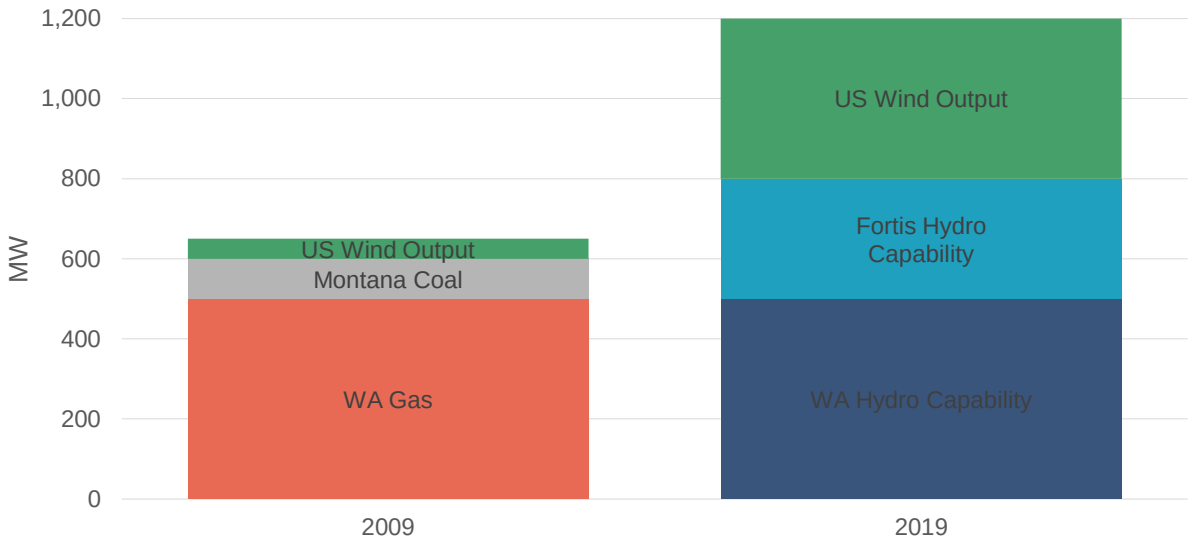
The surplus energy, capacity, flexibility and storage attributes of the BC Hydro system have proven to be valuable resources for jurisdictions and private entities pursuing zero-carbon electricity. Those attributes, together with Powerex's transmission investments, help support the integration of variable forms of renewable generation, enabling the creation of both economic and environmental value in British Columbia and the entire Western region.

Powerex has a long history of delivering low carbon electricity to its customers. Over the past decade, Powerex has sought to help establish and participate in regional reporting frameworks that accurately and transparently track the environmental attributes of its trading activities. For instance, Powerex was one of the first two entities in the West that voluntarily and immediately registered as an "asset-controlling supplier" (ACS) with the California Air Resources Board (CARB) after the establishment of that state's GHG cap-and-trade program. Under the ACS reporting framework, the carbon intensity of Powerex's ACS imports to California is determined by a CARB formula that considers both B.C.'s generation and Powerex's import and export activity to and from B.C. In 2019, Powerex's ACS imports to California are considered 95%[2] lower in emissions than the standard "unspecified" wholesale energy product imported from elsewhere in the West.

Powerex has also already taken steps to reduce the GHG emissions of its U.S. supply portfolio. Ten years ago, Powerex largely relied on a combination of the BC Hydro system, the Canadian Entitlement and supply contracts with fossil fuel generators in the United States to meet its supply obligations. Today, Powerex has largely moved away from those fossil fuel supply contracts, replacing that generation with a combination of additional hydropower and wind energy contracts (Figure 5).

[2] As an ACS, Powerex has a CARB-assigned emission factor updated each year. In Data Year 2019, the CARB-assigned emission factor for Powerex was 0.0233 metric tons of CO_2e per MWh. For comparison, the default emissions factor is 0.428 metric tons of CO_2e per MWh.

*Figure 5: Powerex Forward Portfolio**



***Note: does not include BC Hydro system or Canadian Entitlement**

Powerex's trading and marketing activities associated with the surplus capabilities of the BC Hydro system are one of Powerex's many commercial activities that collectively provide financial benefits to residents of British Columbia in three different ways:

1. Powerex pays the Province the wholesale market value of the Canadian Entitlement supply. Over the past five fiscal years, that annual payment has averaged $134 million.

2. Powerex purchases any BC Hydro system surplus supply under a Transfer Price Agreement; this has resulted in payments to BC Hydro averaging $112 million over the past five fiscal years.

3. Powerex's Net Income, which is derived from a wide range of trading and marketing activities, is used by BC Hydro to lower rates for BC Hydro's customers. Over the past five fiscal years, Powerex's Net Income has averaged $179 million per year.

III. Powerex utilizes the surplus capabilities of the BC Hydro system to provide battery-like services, providing value to the Province and broader West.

The BC Hydro system produces more electric *energy*, on average, than is needed to serve BC Hydro demand, providing a source of surplus energy that can be marketed to external customers. However, in most periods the system also has surplus *capacity*, *flexibility* and *storage* capabilities, collectively referred to as its "surplus capabilities." Those surplus capabilities are what enable Powerex to provide myriad products and services to an integrated Western market with rapidly increasing levels of renewable generation. What differentiates the BC Hydro system from that of others in the West is its combination of size and storage. With BC Hydro's system, water can be stored behind dams and released later when needed. This capability frequently enables energy to be exported to neighboring jurisdictions during the highest valued periods (such as evening hours) when their load is high but solar and wind generation is low.

Powerex's import trade activity further increases the amount of energy available from the BC Hydro system for use during high value periods. The ability to import energy in one period and support incremental sales in another period effectively allows B.C. to provide "battery-like" services to the West. Powerex uses this capability to the mutual benefit of B.C. residents and the West as a whole by purchasing power from outside B.C. when it is inexpensive – enabling BC Hydro to serve its demand while conserving water – and then selling power back to the West when it is more valuable.

Variable generation like wind or solar produce energy when the wind is blowing or the sun is shining. These resources sometimes produce more energy than the grid can absorb, necessitating "curtailment" to prevent excess power from flowing onto the grid. Energy storage technologies are expected to play an important role in reducing both curtailment and emissions by utilizing excess renewable energy for charging and discharging during hours when it is possible to reduce fossil fuel combustion and its associated emissions. Powerex's ability to provide battery-like services creates important financial and environmental benefits to British Columbia and the West:

- ***Financial benefits*** accrue to both British Columbia and Powerex's customers across the West through Powerex's ability to purchase energy during low-priced periods and sell during high-priced periods. Customers in B.C. benefit because Powerex's profits are returned to BC Hydro and used to reduce electricity costs in the Province. Customers across the West benefit because Powerex not only provides clean energy but also clean battery-like services at costs that are below the cost of alternative storage technologies.

- Powerex's activities produce ***Environmental Benefits*** by decreasing the total amount of fossil fuel generation used outside British Columbia during periods when renewable output is low. As illustrated in Figure 6, Powerex's battery-like services allow the receipt of the West's clean solar energy during mid-day hours and the return of this clean energy in the early morning, evening, and at night, displacing natural gas or coal-fired generation.

Figure 6: Illustration of Battery Like Services

IV. Given shifts in Western markets, Powerex suggests exploring incremental changes to electricity sector policy and practices in order to maintain and expand the benefits it delivers.

British Columbia's electricity system operates in a rapidly shifting Western energy policy and market landscape.

100% clean energy has emerged as a premium product for customers across the West. In that context, Powerex has increasingly received requests for 100% clean energy from its customers, often as a preferred product to Powerex's existing low carbon offerings. This demand has come primarily from load-serving entities (LSEs) in California, although large commercial and industrial customers across the West, particularly in the technology sector, have expressed interest and this trend is likely to intensify in the future as more jurisdictions move in the direction of 100% clean energy standards. Powerex will be best able to serve customers across the West — and thereby deliver financial and environmental benefits to British Columbia — if it is positioned to sell 100% clean electricity, and to do so in a highly credible and transparent way.

Powerex's ability to respond to new and emerging customer needs — and earn revenues that support electrification in B.C. and enable GHG reductions in other regions — would be significantly improved if the Province's energy and environmental policies were aligned with other governments in the West. In particular, Powerex suggests three strategic priorities for BC Hydro and the Province:

1. ***Explore establishing a 100% clean energy standard commitment for B.C.***

2. ***Explore mutual recognition and alignment between B.C. and other Western states on GHG pricing policies.***

3. ***Consider the benefits of a regional perspective in future provincial electricity sector policies and in the future resource planning of the BC Hydro system.***

Each of these recommendations is discussed in turn below.

1. Explore establishing a 100% clean energy standard commitment for BC Hydro and Powerex.

In the past year, 100% clean policies and utility commitments have spread throughout the West. These commitments mean that both Western states and private electricity customers will apply increasingly high standards on imported electricity. Powerex will be best positioned to meet these standards if BC Hydro also adopts a 100% clean energy standard.

In the British Columbian context, such a target might encompass requiring 100% clean energy in sufficient quantity to meet BC Hydro's annual average load[3] ***and*** Powerex's clean exports to its customers from BC Hydro generation and imports of verified clean supply[4]. Inclusion of imports is necessary to ensure that achieving 100% clean energy standard is done at manageable cost, thereby furthering B.C.'s related goals of maintaining affordable rates and promoting electrification. Importantly, this approach to a 100% clean energy standard requires that any fossil fuel generation in the Province, as

[3] Due to annual variations in hydro power availability, such a metric should be measured on a rolling basis over a number of years.
[4] The intent of verification is to establish that the seller of the clean supply has not replaced that supply with higher emitting generation.

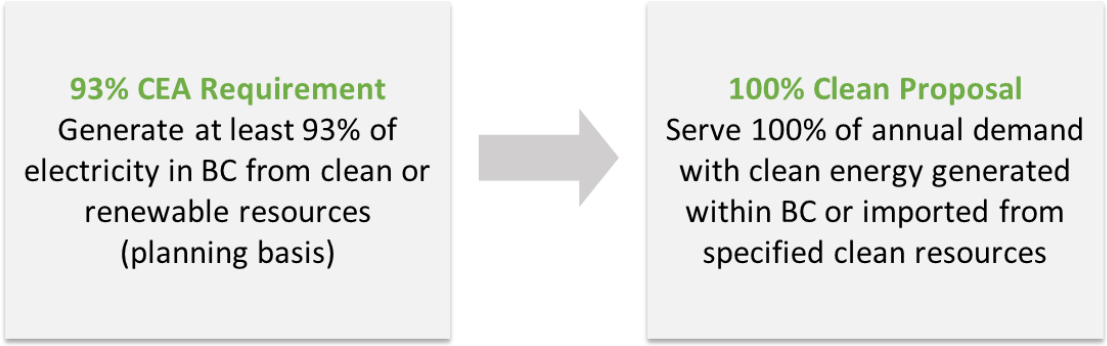
well as any imports that were not verified clean supply, be either curtailed or offset by exports that are not sold as clean. This approach is further discussed in Appendix A.

In addition to achieving alignment with neighboring jurisdictions, a 100% clean energy standard commitment for BC Hydro would also position Powerex to develop and promote a verified “100% clean” commercial product. Powerex would work with others in the industry to develop this product based on a transparent calculation methodology and independent third-party verification. Powerex would continue its commitment to transparency and disclosure of its supply portfolio (i.e., internal BC Hydro generation and Powerex imports) and its clean commitments (i.e., BC Hydro load and Powerex clean exports) as well as unspecified export commitments.

An affordable 100% clean energy standard may also provide additional benefits within B.C., as it would improve the attractiveness of the region to industries and customers that include the availability of 100% clean affordable electricity in their business decisions.

Figure 7 summarizes different definitions and proposal of 100% clean energy standard

Figure 7: Today vs 100% Clean



Note: For the purpose of discussion, the 100% clean energy standard could be defined as the amount of energy from clean sources within B.C. or imported into B.C. equal or exceeding 100% of the average annual energy consumed within B.C. Performance with this requirement may be measured on an annual basis based on the average of multiple years to account for annual hydrology variation (e.g. the previous four years) as described further in Appendix B.

2. Explore mutual recognition or alignment between B.C. and Western states’ electricity sector GHG policies.

The West now includes three jurisdictions with binding economy-wide GHG emissions reductions commitments: British Columbia, California and, most recently, Colorado. B.C. and California rely on combinations of emissions pricing, technology incentives and technology mandates to achieve GHG reductions. In addition to states and provinces with binding commitments, several other Western states have set GHG reductions targets and implemented a variety of non-price-based policies to achieve those targets.

Today, Western GHG reduction initiatives exhibit little coordination. While there are ongoing forums for discussing climate policy coordination across the West, in practice state and provincial initiatives operate mostly independently. Such a patchwork regional approach to GHG policy holds the potential to create inefficiencies in the operation of Western markets including electricity. Inefficiencies lead to reductions in mutually beneficial trade between regions, with consequences ranging from unnecessary curtailment of zero-emissions generation to customer cost burdens from double-taxation of imports.

A potential solution to these issues is to seek mutual recognition or harmonization of B.C.'s GHG reduction initiatives with those other jurisdictions. A potential starting place would be to work towards a GHG price reciprocity agreement with California. Climate policy reciprocity between B.C. and California could take several forms but would generally seek to ensure that energy transfers between the two regions are not subject to duplicative GHG-related obligations. Importantly, a reciprocity framework developed between B.C. and California could serve as the basis for a larger program as additional Western jurisdictions further their GHG policy-ambitions.

3. Consider the benefits of a regional perspective in future electricity sector policies and in the resource planning of the BC Hydro system.

British Columbia has a unique role in the Western electricity system, with substantial opportunities available to the Province when it engages in trade with its neighbors. Policies and resource planning decisions should consider that unique role, incorporating a regional perspective along with local considerations. In practice, this means considering how policy and planning decisions affect the ability of the BC Hydro system to provide surplus energy, capacity, flexibility, and storage attributes to customers throughout the West. Providing those services furthers the Province's dual goals of ensuring affordable electricity and achieving deep GHG emissions reductions.

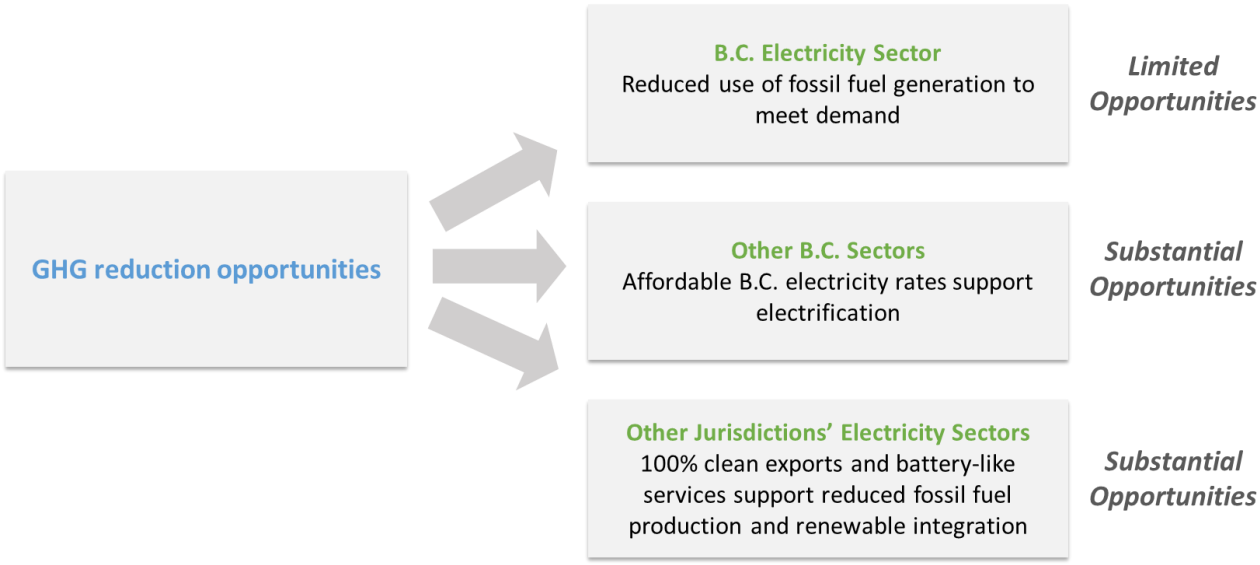
Benefits of Policy and Planning Alignment

The policy and planning alignment opportunities described above would ensure that Powerex is best positioned to continue to deliver economic benefits to British Columbia and support the Province in its environmental goals. First, achieving credible decarbonization in B.C., while maintaining or expanding BC Hydro's surplus capabilities, directly supports Powerex's ability to earn surplus sales and trading revenue, which *helps to keep BC Hydro rates affordable*. Those revenues are also critical to B.C.'s climate policy goals because they *support the electrification of energy-intensive sectors* that currently rely on fossil fuels. Electrification is perhaps the most cost-effective way to leverage B.C.'s electricity sector to reduce GHG emissions *in B.C.,* given that B.C.'s electricity sector is already largely non-emitting.

Meeting Western customers' needs for zero-emissions electricity and battery-like services also allows B.C. to further contribute to GHG reductions in *other regions* that have far more GHG-intensive electricity sectors than British Columbia's. Powerex can enable substantial GHG reductions on the Western electricity grid in two ways. First, Powerex can supply 100% clean (verified) surplus power from the BC Hydro system and Powerex's external supply portfolio to other regions. Given the flexibility of the BC Hydro system, these *transactions will displace external fossil-fueled generation* during the hours of low wind and solar output. Second, Powerex can provide battery-like services to assist in the balancing of renewable resources, particularly solar and wind, in other jurisdictions. An expansion of these services will lead to further emissions reductions across the West.

The following figure summarizes different pathways through which Powerex can support emissions reductions both within B.C. and throughout the West. A more detailed description of the emissions reductions enabled by Powerex's wholesale electricity transactions can be found in Appendix B.

Figure 8: Pathways to GHG Emissions Reductions, Enabled by the BC Hydro System



Conclusion

British Columbia is in the midst of a transition to a low-carbon economy. An important component of that transition is affordable electricity that facilitates emissions reductions in other sectors of the economy via electrification. Powerex plays an important role in keeping electricity rates low in B.C. through revenues earned from its trading activities that are returned to BC Hydro. Powerex also facilitates cost-effective emissions reductions outside British Columbia by providing clean surplus energy and battery-like services that decreases the use of fossil fuel generation in other jurisdictions.

The pace of change in Western electricity markets is accelerating. Commitments to meet 100% of demand with clean electricity are now law in multiple states throughout the West. Several private entities, including utilities and large energy users, have also made their own voluntary commitments to serve 100% of their demand with clean electricity.

Given the capabilities of the BC Hydro system, these shifts represent a substantial opportunity for the Province. Those opportunities would be best realized if there is alignment in policy between B.C. and other leading jurisdictions. To that end, Powerex suggests the following three steps:

1. ***Explore establishing a 100% clean energy standard commitment for BC Hydro, including clean exports.***

2. ***Explore mutual recognition and alignment between B.C. and other Western states on GHG pricing policies.***

3. ***Consider the benefits of a regional perspective in future electricity sector policies and in the resource planning of the BC Hydro system.***

These changes would represent incremental changes to B.C. policy and electricity planning but, from Powerex's perspective, hold the potential to unlock substantial benefits to the Province and broader West. Further exploration of the concepts would require a more comprehensive analysis of the broader impacts of these policies to BC Hydro and the Province.

Appendix A — A 100% Clean Energy Standard for B.C.

Multiple states have enacted legislation to achieve a "100% clean" target. For instance, California passed legislation in 2018 requiring a 100% renewable and clean energy target by 2045. New Mexico and Washington have passed similar legislation, while Nevada has set a 100% clean target to be achieved by 2050. As public support for 100% clean policies grows, and as more jurisdictions move to adopt them, it is important to understand how such policies are applied in the context of an interconnected electricity grid with continuous imports and exports in all hours of the year.

Each jurisdiction has developed its own methodology for how it verifies whether or not renewable or clean energy targets have been met. Generally, however, states require LSEs to procure a total quantity of energy from qualifying sources that is equal to or greater than the respective LSE's retail load, multiplied by the percentage procurement target. Compliance with the requirements is measured over a period of one calendar year or longer.

Below is an excerpt from Pacific Gas & Electric (PG&E)'s preliminary 2017 report to the California Public Utilities Commission (CPUC) demonstrating its compliance with the state's RPS.

Compliance Summary and Charts

	2011	2012	2013	2014	2015	2016	2017
Retail Sales (MWh)	74,863,941	76,205,120	75,705,039	74,546,865	72,112,848	68,440,794	61,397,214
Annual % Target	20.0%	20.0%	20.0%	21.7%	23.3%	25.0%	27.0%
Annual RPS Target	14,972,788	15,241,024	15,141,008	16,176,670	16,802,294	17,110,199	16,577,248
Procurement Quantity Requirement		45,354,820			50,089,162		[redacted]

Resource Mix

	2011	2012	2013	2014	2015	2016	2017
Total RPS Procurement	**14,833,115**	**14,513,109**	**17,079,095**	**20,156,687**	**21,284,772**	**22,489,623**	**20,275,682**
Biomass	3,145,815	3,272,896	3,173,902	3,327,065	2,926,462	2,715,185	1,938,309
Biogas: Digester gas	23,258	7,486	2,278	9,984	12,208	12,767	14,588
Biogas: Landfill gas	126,263	96,020	80,364	101,656	198,827	229,336	258,105
Biodiesel	0	0	0	0	0	0	0
Muni Solid Waste	118,759	4,781	0	0	0	488	5,748
Bioenergy Subtotal	3,414,095	3,381,183	3,256,544	3,438,706	3,137,496	2,957,775	2,216,750
Geothermal	3,777,396	3,803,361	3,681,520	3,868,103	3,664,213	3,705,190	2,796,244
Small Hydro	2,749,996	1,812,601	1,582,748	980,529	878,253	1,800,543	1,946,552
Conduit Hydro	0	0	0	0	0	0	0
Water supply and conveyance	0	0	0	0	0	0	0
Solar PV	214,183	1,170,864	3,629,656	5,605,929	6,598,718	6,849,695	6,806,464
Solar Thermal	0	0	20,581	876,004	1,557,412	1,750,982	1,464,827
Wind	4,677,444	4,345,101	4,908,046	5,387,415	5,448,681	5,425,438	5,044,844
Ocean wave	0	0	0	0	0	0	0
Ocean thermal	0	0	0	0	0	0	0
Tidal current	0	0	0	0	0	0	0
Fuel Cells	0	0	0	0	0	0	0

Source: Pacific Gas & Electric "Preliminary 2017 Annual RPS Compliance Report", Appendix A at 6. RPS submissions to the CPUC for 2017 are available at: ftp://ftp.cpuc.ca.gov/RPS_PPAs/Compliance%20Report%20Archives/

For each year, PG&E's retail load is multiplied by the applicable renewable procurement percentage target to calculate the annual renewable procurement requirement in MWh. This can then be compared to the sum of the renewable energy procured in the same year from qualifying sources. While the data reports have annual granularity, formal compliance with the RPS requirement is assessed over a multi-

year period.[5] For instance, the 2016 procurement requirement is added to the requirements for 2014 and 2015 to yield an aggregate procurement requirement for the compliance period 2014-2016.

Other Western states that have adopted procurement requirements for clean or renewable resources have compliance periods ranging from one year to four years. Procurement requirements defined over a period of a year or longer are generally workable for entities in the context of an interconnected electricity grid in which substantial quantities of imports and exports occur each and every hour. More specifically, the procurement requirements create or expand demand for energy from clean or renewable resources — even as high as 100% of customer demand — but are still compatible with:

1. Electricity production from existing fossil-fueled generation within the jurisdiction; and
2. Imports into the jurisdiction of energy that are not explicitly sourced from qualifying clean or renewable sources.

In considering how a "100% clean" energy standard could be adopted by BC Hydro, Powerex believes it is important to account for exports from the BC Hydro system that are explicitly designated by Powerex as being from clean generation resources. Such specified-source deliveries are an increasingly important part of commercial activity to or from regions with GHG programs, including California. Therefore, a clean energy standard should be sufficient not only to meet BC Hydro load, but also to meet any export quantities sold by Powerex as expressly carbon-free products.

The following hypothetical example illustrate how the above definition would be applied under various conditions regarding domestic demand, internal generation, and import/export activity.

Scenario 1:

The first scenario reflects a highly simplistic case in which total domestic demand (50,000 GWh) is equal to total generation from internal non-emitting resources (also 50,000 GWh). There are no imports or exports in this example. This scenario is self-evidently consistent with a "100% clean" target, as shown below:

Supply and Demand Type	**Total GWh**
Domestic generation — non-emitting	50,000
Domestic generation — emitting	-
Imports — specified non-emitting	-
Imports — unspecified	-
Total clean supply	**50,000**
Domestic demand	50,000
Exports — specified non-emitting	-
Exports — unspecified	-
Clean supply required for 100%	**50,000**
	PASS

[5] CPUC "RPS Compliance Frequently Asked Questions (FAQs)" at 1. ("Compliance with the RPS program is determined by the CPUC for multi-year compliance periods that are set in statute and adopted in CPUC decisions. While formal compliance with the program is not determined annually, retail sellers are required to submit annual preliminary Compliance Reports to the CPUC that contain historical and forecasted data about their renewable procurement. The CPUC evaluates these annual reports to ensure progress is being made towards the interim annual targets.") *Available at:* https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442459444

Scenario 2a:

The “100% clean” target can also be achieved when 40,000 GWh of internal non-emitting generation is complemented by 10,000 GWh of imports from specified non-emitting resources:

Supply and Demand Type	Total GWh
Domestic generation — non-emitting	40,000
Domestic generation — emitting	-
Imports — specified non-emitting	10,000
Imports — unspecified	-
Total clean supply	**50,000**
Domestic demand	50,000
Exports — specified non-emitting	-
Exports — unspecified	-
Clean supply required for 100%	**50,000**
	PASS

Scenario 2b:

Note, however, that the 100% clean target would *not* be achieved if the 10,000 GWh of energy imports needed to serve domestic demand included imports from unspecified sources, or from specified sources that were not non-emitting.

Supply and Demand Type	Total GWh
Domestic generation — non-emitting	40,000
Domestic generation — emitting	-
Imports — specified non-emitting	7,000
Imports — unspecified	3,000
Total clean supply	**47,000**
Domestic demand	50,000
Exports — specified non-emitting	-
Exports — unspecified	-
Clean supply required for 100%	**50,000**
	FAIL

As shown above, total clean supply in this scenario would be less than domestic demand, and hence the 100% clean target would not be achieved.

Scenario 3:

It is also possible to achieve the 100% clean target even if there is some production from domestic GHG-emitting resources, provided that production does not lead to reduced supply from non-emitting resources. In the following two panels, 2,000 GWh of energy exports enable total energy supply to equal total energy demand. In the right-hand panel, however, those exports are delivered as being from specified non-emitting resources. This causes the 100% clean target to not be achieved, however, because such specified exports increase the total clean supply requirement to 52,000 GWh, which exceeds the actual clean supply of 50,000 GWh. In the left-hand panel, the energy exports are identified as unspecified-source deliveries, which appropriately maintains the balance between clean supply and clean energy commitments.

Supply and Demand Type	Total GWh
Domestic generation — non-emitting	50,000
Domestic generation — emitting	2,000
Imports — specified non-emitting	-
Imports — unspecified	-
Total clean supply	**50,000**
Domestic demand	50,000
Exports — specified non-emitting	-
Exports — unspecified	2,000
Clean supply required for 100%	**50,000**
	PASS

Supply and Demand Type	Total GWh
Domestic generation — non-emitting	50,000
Domestic generation — emitting	2,000
Imports — specified non-emitting	-
Imports — unspecified	-
Total clean supply	**50,000**
Domestic demand	50,000
Exports — specified non-emitting	2,000
Exports — unspecified	-
Clean supply required for 100%	**52,000**
	FAIL

To the extent that there were exports delivered as specified non-emitting supply, such exports would be possible only if there was a corresponding increase in the total clean supply, as shown below:

Supply and Demand Type	Total GWh
Domestic generation — non-emitting	52,000
Domestic generation — emitting	-
Imports — specified non-emitting	-
Imports — unspecified	-
Total clean supply	**52,000**
Domestic demand	50,000
Exports — specified non-emitting	2,000
Exports — unspecified	-
Clean supply required for 100%	**52,000**
	PASS

The above example highlights a critical feature of the 100% clean framework: its purpose is to require the production or procurement of clean energy in a quantity equal to 100% of the domestic demand for energy *plus* any energy exports represented as being clean supply. This target, while aggressive, is not equivalent to a prohibition on the dispatch of GHG-emitting internal resources, nor does it require a prohibition on energy imports from sources other than verified clean resources. That target does require, however, that any unspecified imports or any production from GHG-emitting resources do not lead to a reduction in the quantity of clean supply.

Scenario 4:

The prior example illustrates that any production from a GHG-emitting resource requires exports of unspecified energy in order to avoid reducing the total quantity of clean supply that is procured. This requirement applies over a defined period of time. Compliance with California's RPS is evaluated over a three-year compliance period, and Powerex is not aware of any clean program that measures compliance over a period of less than one year. This means that clean supply sources may be less than domestic demand and verified clean exports over an isolated subset of the full compliance period, while still being entirely consistent with achieving the 100% clean target.

The following example shows Scenario 3a, but disaggregated into two equal sub-periods. Period 1 is when the 2,000 GWh of production from GHG-emitting internal resources occurs. On a stand-alone basis, the total clean supply in Period 1 is less than the domestic demand in Period 1. However, in Period 2, the total clean supply exceeds domestic demand by the same amount, which results in total clean supply being equal to total domestic demand over the full evaluation period.

	GWh		
Supply and Demand Type	Period 1	Period 2	Total
Domestic generation — non-emitting	23,000	27,000	50,000
Domestic generation — emitting	2,000	-	2,000
Imports — specified non-emitting	-	-	-
Imports — unspecified	-	-	-
Total clean supply	**23,000**	**27,000**	**50,000**
Domestic demand	25,000	25,000	50,000
Exports — specified non-emitting	-	-	-
Exports — unspecified	-	2,000	2,000
Clean supply required for 100%	**25,000**	**25,000**	**50,000**
			PASS

The export in Period 2 bears additional focus: even though all generation in Period 2 was from non-emitting resources, the export *cannot* be delivered as specified-source clean energy. Doing so would increase the total clean supply necessary to achieve the 100% clean target above the actual levels of clean supply, as shown below.

	GWh		
Supply and Demand Type	Period 1	Period 2	Total
Domestic generation — non-emitting	23,000	27,000	50,000
Domestic generation — emitting	2,000	-	2,000
Imports — specified non-emitting	-	-	-
Imports — unspecified	-	-	-
Total clean supply	**23,000**	**27,000**	**50,000**
Domestic demand	25,000	25,000	50,000
Exports — specified non-emitting	-	2,000	2,000
Exports — unspecified	-	-	-
Clean supply required for 100%	**25,000**	**27,000**	**52,000**
			FAIL

The evaluation of a 100% clean target over a period of one year or longer is also critically important in order to continue to make the most efficient use of energy-limited hydro resources with longer-term storage, such as those owned and operated by BC Hydro. Very significant efficiency benefits, cost savings, and trade revenue are enabled by the flexibility of the BC Hydro system. These benefits would be largely eliminated if a 100% clean energy standard was interpreted as requiring non-emitting supply to match domestic demand each and every hour of the year. Such an interpretation would make a 100% clean energy standard prohibitively costly, and operationally unworkable, in addition to being entirely inconsistent with how similar clean policies are being defined in other jurisdictions. Moreover, such an interpretation is not necessary in order to enable GHG reductions. In the above example, the exports in Period 2 will, by definition, displace production from external generating resources that would otherwise be needed to serve demand in the receiving jurisdiction. A storage hydro system such as BC Hydro generally enables export transactions to be maximized during periods of greatest value (*i.e.,* when Powerex is able to realize the highest market price). These are precisely the times in which the marginal resource in the region is most likely to be a less efficient fossil-fueled resource with relatively high GHG emissions. In other words, the GHG emissions from internal generation in Period 1 are like to be fully offset by the avoided GHG emissions from external resources displaced by the exports in Period 2, resulting in either GHG-neutral or net GHG reductions over the full evaluation period.

Appendix B — Western GHG Reductions Enabled by Powerex's Wholesale Electricity Transactions

Overview

Powerex is the exclusive marketer of the surplus energy and capabilities of the BC Hydro system as well as the Province's Canadian Entitlement supply provided under the Columbia River Treaty. In that role, Powerex works to ensure that exports from the BC Hydro system are put to their highest and best uses through sales transactions in Western wholesale electricity markets.

In addition to arranging for export sales supported by surplus energy from the BC Hydro system and the Canadian Entitlement, Powerex also engages in offsetting import and export activity utilizing the residual capacity, flexibility and storage capabilities of the BC Hydro system. When Powerex purchases energy in wholesale electricity markets and imports that energy into the BC Hydro system, it enables additional water to remain impounded behind BC Hydro's dams, which in turn influences the future operation of the system, including the ability to export additional energy.

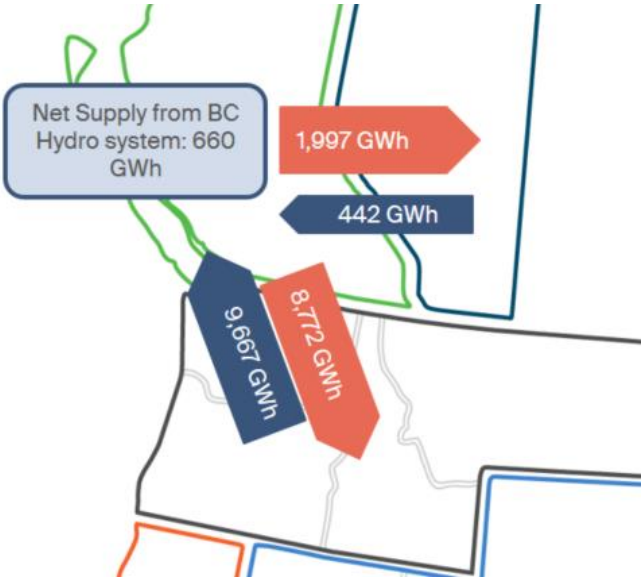
The causal link between imports in one time period and additional exports in other time periods is not present in electric power systems that rely primarily on fossil-fueled generation. Imports into a grid consisting of natural gas and coal generation, for example, would reduce the amount of electricity produced by those resources. The imports would have little or no impact on the ability of those fossil-fueled resources to produce electricity in the future, however, since the necessary fuel is always available for purchase. In an energy-limited storage hydro system such as the BC Hydro system, the "fuel" is the water inflows into the major reservoirs. Imports into a storage hydro system do not reduce the total quantity of "fuel" that will be used over time, since water inflows must ultimately be used to generate electricity or otherwise risk being spilled. Instead, all else being equal, imports increase the quantity of generation that will need to occur at a different point in time in order to avoid exceeding the storage limits of the system. And since, on a multi-year basis, the energy available from the BC Hydro system exceeds the needs of BC Hydro's customers, this increased future generation will generally require increased future exports out of the BC Hydro system.

The foregoing means that ***Powerex's imports of energy from external regions must at some point be offset by additional exports of energy out of the BC Hydro system*** for delivery to entities in external regions.[6] Any evaluation of Powerex's import activity would be incomplete, unreliable, and potentially misleading if it fails to also consider the export activity that goes hand-in-hand with those imports.

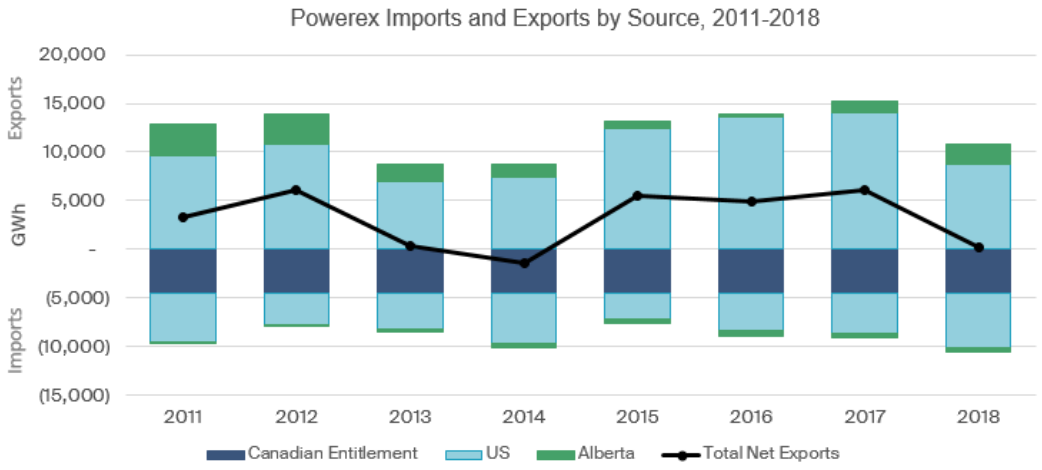
The relationship between Powerex's gross imports, Powerex's gross exports, and the net supply from the BC Hydro system is illustrated below, with imports and exports differentiated between Alberta and the Western U.S.

[6] In a limited number of hours per year Powerex may import energy, typically at negative prices, that does not result in the conservation of water and offsetting exports in other periods as the BC Hydro system is at minimum generation levels and instead spills additional water. In these limited circumstances, however, these imports are occurring during periods of oversupply in Western markets where the import activity is reducing the curtailment of hydro, wind or solar output, *not* resulting in the increase in external fossil fuel production.

Powerex Gross Exports/Imports 2018



Powerex's annual imports and exports to and from the BC Hydro system since 2011 are presented below, separated between the U.S. and Alberta.[7]



This appendix provides an estimate of the overall potential impact of Powerex's aggregate trade activity on GHG emissions from electricity generation. Given that Powerex's imports into the BC Hydro system cannot be viewed in isolation from Powerex's exports out of the BC Hydro system or from electricity generated within B.C. itself, the estimate explicitly considers GHG emissions associated with three activities:

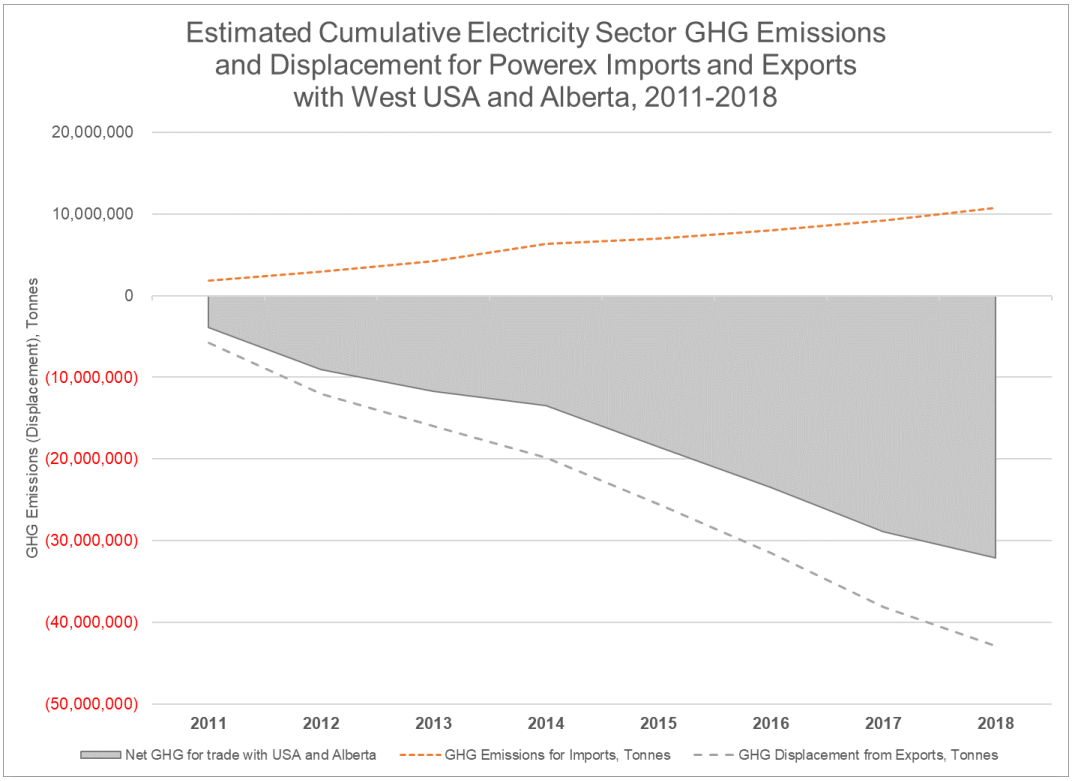
1. GHG emissions inside British Columbia related to electricity generation within the BC Hydro system;

[7] Alberta imports/exports are for all entities, not only Powerex, as explained further in Methodology and Data Sources.

2. GHG emissions in external areas associated with electricity imported by Powerex into the BC Hydro system; and
3. Reduced GHG emissions in the electricity sector in external areas receiving energy exported by Powerex from the BC Hydro system, as these deliveries displace electricity generation in the receiving area.

Based on this approach, it is estimated that Powerex's wholesale electricity transactions in the West have enabled an estimated net reduction in electricity sector GHG emissions totaling over 32 million $MTCO_2$ over the period 2011 to 2018. This is comprised of a net reduction of 5.9 million $MTCO_2$ related to Powerex's transactions with Alberta, and a net reduction of 26.3 million $MTCO_2$ related to Powerex's transactions with entities in the Western U.S.

The chart below shows the cumulative estimated impact on GHG emissions in the electricity sector from electricity production for each year from 2011 to 2018 in the Western U.S. and Alberta[8]. The electricity sector GHG emissions associated with Powerex's gross imports are shown as the orange dotted line, while the GHG emissions avoided by generation displaced in areas receiving Powerex's gross exports are shown as the gray dotted line. The net change in the electricity sector GHG emissions is shown as the gray area.



The analysis is based on the published Western Climate Initiative (WCI) marginal GHG emission rate for electricity generators in Alberta and in the Western U.S. However, these emission rates are not differentiated by time of day or season of the year. Powerex believes it is highly likely that this analysis therefore overstates the actual GHG emissions associated with Powerex's imports, and also understates

[8] See Supplemental Data for the Western U.S. and Alberta separately.

the power generation GHG emissions displaced by Powerex's exports. More specifically, in pursuit of its corporate mandate to earn trade income, Powerex generally makes wholesale purchases and imports when prices are relatively low. This largely corresponds to the hours of the day or time of year when there is abundant production of electricity from variable energy resources including solar, wind, or run-of-river hydro generation. Under such conditions, the GHG emissions for electricity production is therefore likely to be less than the average emissions rate used in the analysis — potentially far less.

Similarly, Powerex generally makes wholesale sales and exports when market prices are relatively high. This largely corresponds to the hours of the day or times of the year in which energy is produced from more expensive resources, including less efficient fossil-fueled generation with higher GHG emission rates. Consequently, Powerex's exports from the BC Hydro system during such conditions will displace electricity production from regions experiencing GHG emissions rates that are likely considerably higher than the average emission rate across all hours of the year that is used in the analysis.

Methodology and Data Sources

The analysis utilizes publicly available data regarding electricity imports and exports from B.C., and on GHG emissions for B.C. More specifically, the following data sources are used in the analysis:

- Powerex's gross electricity imports from the U.S. to B.C., and its gross electricity exports to the U.S. from B.C., are reported on a monthly basis to the Canadian Energy Regulator (CER).[9]
- The Canadian Entitlement average annual energy is available from the U.S. Army Corps of Engineers in the Assured Operating Plan and Determination of Downstream Power Benefits.[10]
- Gross electricity imports from Alberta to B.C. and gross electricity exports from B.C. to Alberta are reported on a monthly basis to Statistics Canada. This analysis attributes all such volumes to Powerex.[11]
- GHG emissions associated with Powerex's imports into B.C. are reported annually to the Province's Ministry of Environment.[12]

The calculations performed using these data sources are described below.

Disaggregating GHG emissions on imports from Alberta and from the Western U.S.:

The public data on annual GHG emissions associated with imports are not disaggregated between imports from Alberta and imports from the Western U.S. To estimate the disaggregation of these GHG emissions, the gross import volume from Alberta to B.C. is multiplied by the average GHG emission factor for Alberta, equal to 0.522 $MTCO_2$/MWh.[13] The remainder of the total import GHG emissions is attributed to imports from the Western U.S., which are a combination of Canadian Entitlement supply under the

[9] https://apps.cer-rec.gc.ca/CommodityStatistics/Statistics.aspx?language=english
[10] https://www.nwd.usace.army.mil/CRWM/PEB/CRT-Documents/
[11] https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=2510001601
[12] https://www2.gov.bc.ca/gov/content/environment/climate-change/data/industrial-facility-ghg
[13] In 2008, the WCI developed estimates of the average GHG emission rates for electricity generation for various states and provinces. These estimates have been adopted for use in GHG emission reporting to various regulatory bodies, including the CARB and the B.C. Ministry of Environment. As is relevant in this appendix, the average GHG emissions factor is 0.522 $MTCO_2$/MWh for Alberta and 0.428 $MTCO_2$/MWh for the Western U.S. Material related to the WCI default emissions factor calculations is available at: http://westernclimateinitiative.org/index.php?option=com_remository&Itemid=37&func=select&id=39

Columbia River Treaty, Powerex's purchases of specified-source non-emitting supply, and Powerex's purchases of unspecified-source energy.

Estimating Electricity Sector GHG emissions displaced by Powerex exports to AB and Western U.S.[14]

Powerex's gross exports enabled a reduction in generation by the receiving entity, and a reduction in associated GHG emissions. The GHG emissions from generation displaced by Powerex's gross exports to Alberta are estimated by multiplying the export volume by the average GHG emission factor for Alberta of 0.522 $MTCO_2$/MWh. Similarly, the GHG emissions from generation displaced by Powerex's gross exports to the Western U.S. are estimated by multiplying the export volume by an average GHG emission factor of 0.428 $MTCO_2$/MWh, based on the default emission factor for unspecified source energy adopted by the CARB.

Estimating GHG emission associated with net supply from the BC Hydro system:

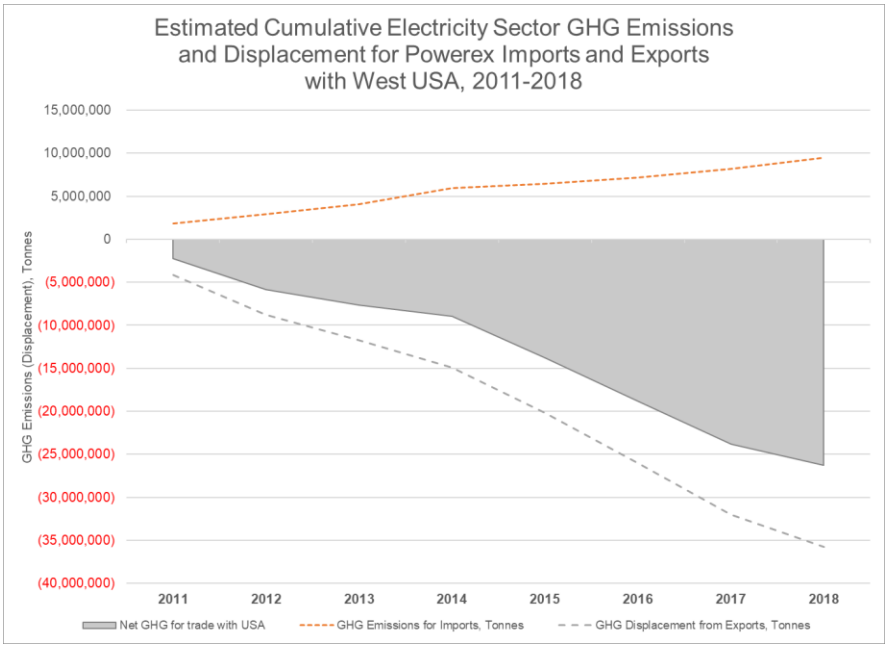
To the extent Powerex's gross exports out of B.C. exceed Powerex's gross imports into B.C. in a given year, the difference in volume is imputed to represent generation from the BC Hydro system. The GHG emissions associated with this generation could be estimated as the product of the above volume and the GHG emission rate for BC Hydro generation of 0.009 $MTCO_2$/MWh[15]. Given that BC Hydro's generation resources are approximately 95% non-emitting hydroelectric resources, the additional GHG emissions associated with additional production from the BC Hydro system are immaterial in the context of this analysis. For instance, over the period 2011-2018, Powerex's gross exports exceeded Powerex's gross imports by an average of 3,424 GWh per year. Applying the average GHG emission factor for B.C. electric generation of 0.009 $MTCO_2$/MWh yields GHG emissions of 30,812 $MTCO_2$ per year, which represent approximately 0.8% of the estimated net GHG emissions displaced by Powerex's import and export activity over the period.

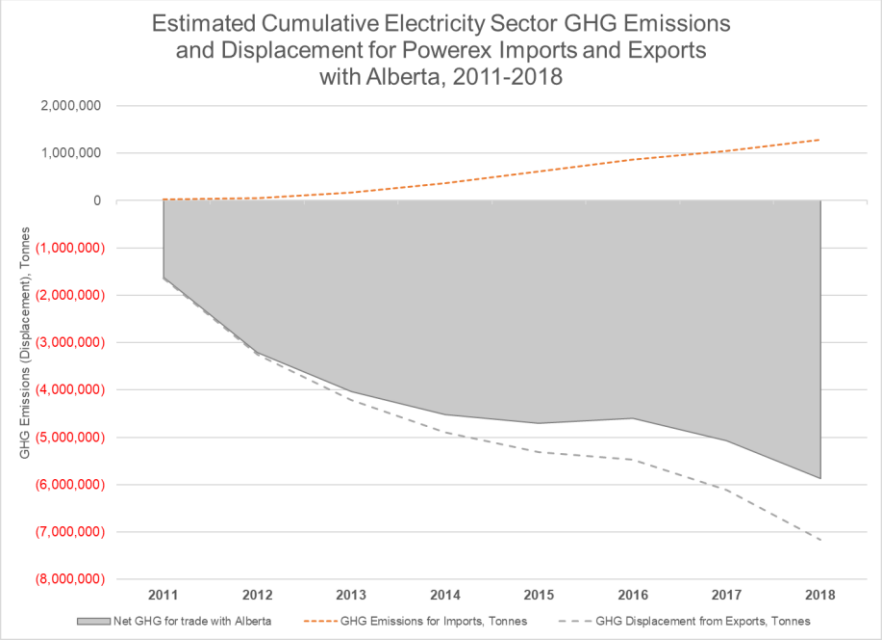
[14] In 2013 California began regulating the GHGs associated with the production of electricity inside California and the GHGs attributed to deliveries of electricity into the state. Estimates of displaced emissions in this section are limited to a simple estimate of emissions directly displaced in the electricity sector through the delivery of clean electricity from B.C. to California and is not intended to account for the broader effects of California's Cap-and-Trade Program. Under the California Cap-and-Trade Program, it is the total emissions cap that sets the total amount of emissions in the state.

[15] In past years, BC Hydro reported annual average GHG emission factors for its generating facilities. This analysis uses the emission factor from the last reported year. BC Hydro's reported emission factors are available at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/environmental-reports/ghg-intensities-2007-2015.pdf

Supplemental Data:

The cumulative estimated impact on electricity sector GHG emissions is shown separately for import and export activity with entities in the Western U.S. (top chart) and with Alberta (lower chart). For each chart, the electricity sector GHG emissions associated with Powerex's gross imports are shown as the orange dotted line, while the GHG emissions avoided by generation displaced in areas receiving Powerex's gross exports are shown as the gray dotted line. The net change in the electricity sector GHG emissions is shown as the gray area.





Emissions from Electricity Import Operations, $MTCO_2$ (B.C. Ministry of Environment)[16]

Year	2011	2012	2013	2014	2015	2016	2017
B.C. Total	1,936,329	1,157,500	1,341,919	2,148,845	752,029	1,018,537	1,262,737
Powerex	1,877,145	1,084,554	1,253,491	2,099,878	721,522	976,320	1,201,426

B.C. and Powerex Imports and Exports, GWh (Canada Energy Regulator and Statistics Canada)[17]

Year		2011	2012	2013	2014	2015	2016	2017	2018
Alberta	Exports	3,152	3,088	1,818	1,311	810	301	1,241	1,997
	Imports	(41)	(62)	(224)	(384)	(460)	(495)	(350)	(442)
	Net Exports	3,110	3,026	1,594	926	350	(194)	891	1,555
US	Exports	9,940	11,065	7,083	7,528	12,486	13,720	14,196	8,926
	Powerex	9,656	10,838	6,921	7,394	12,389	13,550	13,972	8,772
	Imports	(10,152)	(8,061)	(8,473)	(9,698)	(7,042)	(8,263)	(8,597)	(10,090)
	Powerex	(9,533)	(7,630)	(8,001)	(9,425)	(6,798)	(8,034)	(8,274)	(9,667)
	Net Exports	(211)	3,005	(1,390)	(2,171)	5,445	5,458	5,599	(1,164)
	Powerex	123	3,207	(1,081)	(2,031)	5,591	5,516	5,698	(895)
Total	Exports	13,092	14,153	8,901	8,838	13,297	14,022	15,438	10,922
	Imports	(10,193)	(8,122)	(8,697)	(10,083)	(7,501)	(8,758)	(8,947)	(10,532)
	Net Exports	2,899	6,031	204	(1,244)	5,795	5,264	6,490	391

Asset Controlling Supplier (ACS) Rate[18]

Powerex reports on the GHG intensity of the entire BC Hydro system (including all sources of supply, imports, and exports from specific facilities) to the CARB under Section 95111(b)(3) of the Mandatory Reporting Regulation for the purpose of assigning GHGs to Powerex's imports to California from the BC Hydro system. Powerex's "Asset Controlling Supplier" rate is shown below:

Generation Year	2011	2012	2013	2014	2015	2016	2017
CARB Data Year	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Powerex ACS rate (MT CO2e per MWh)	0.0293	0.0216	0.0355	0.0469	0.0205	0.0254	0.0233

The "Generation Year" reflects year of Generation/Import/Export and aligns with the years in the previous tables. Deliveries to California from the BC Hydro system in any particular period are assigned the "Data Year" intensity for the year that the energy is delivered as opposed to the "unspecified" electricity rate of 0.428 MT CO_2e per MWh. Powerex's reporting to CARB is subject annual 3rd Party verification.

[16] https://www2.gov.bc.ca/gov/content/environment/climate-change/data/industrial-facility-ghg (Accessed 2019-09-09)

[17] Canada Energy Regulator: https://apps.cer-rec.gc.ca/CommodityStatistics/Statistics.aspx?language=english (Accessed 2019-09-05)
Statistics Canada: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510001601 (Accessed 2019-09-05)

[18] See https://ww2.arb.ca.gov/mrr-acs.