



Canadian Hydropower Exports to the Northeast U.S.

New Transmission Corridors Linked to Potential New Dams

EXECUTIVE SUMMARY

Hydro-Quebec (HQ) (Quebec’s provincially-owned utility) currently plans to increase the amount of hydroelectricity it exports to Massachusetts and New York by a total of up to 2,450 megawatts (MW) and 19.83 terawatt-hours (TWh).¹ The exports would use two proposed transmission corridors that would further tie HQ’s system to U.S. markets. A proposed transmission corridor to Massachusetts, the New England Clean Energy Connect (NECEC),² would snake through the wilderness of northern Maine and eventually connect to Massachusetts, with a planned delivery date as early as 2022. A second proposed transmission corridor, to serve New York City, the Champlain Hudson Power Express (CHPE), would traverse under Lake Champlain, the Hudson River, the East River, and the Harlem River with additional sections buried underground.³

In addition, in January 2020, HQ announced it signed an agreement with the New Brunswick’s NB Power for a total of 47 TWh (for an annual average of 2.35 TWh) beginning immediately and continuing to 2040, while calling “for discussions to begin regarding the construction of additional interconnections between Quebec and New Brunswick, to increase electricity exports to Atlantic Canada and the United States.”⁴

HQ’s major generating stations and transmission lines, including interties to the U.S. are shown in Figure 1.

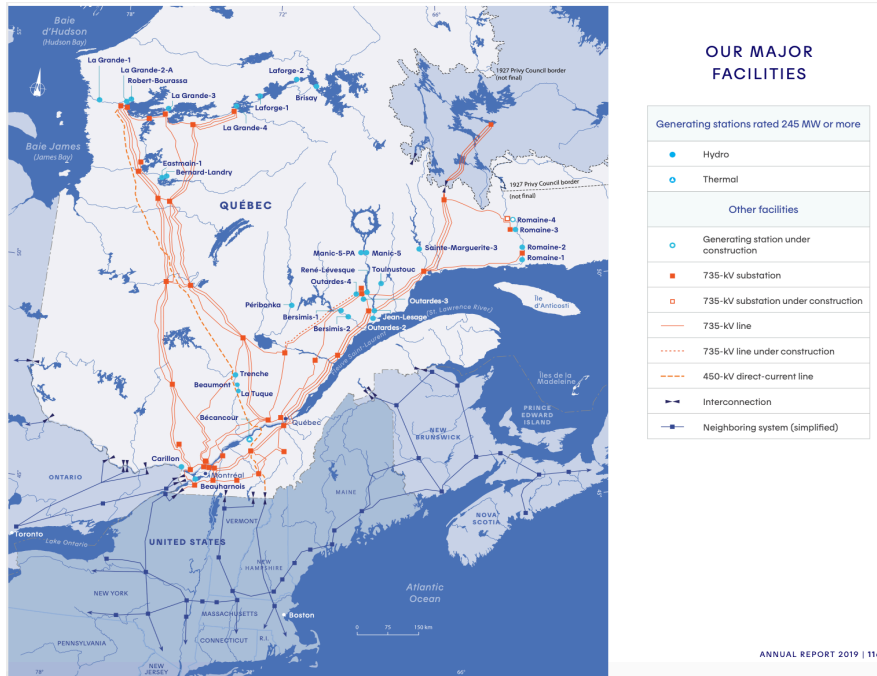


Figure 1: Hydro-Quebec's System
Source: HQ 2019 Annual Report

In 2019, HQ's net exports totaled 33.7 TWh.⁵ If those exports are not backed off to make room for new commitments, and one adds NECEC and CHPE commitments of up to 19.83 TWh, as well as New Brunswick's 2.35 TWh, the sum of these exports would equal 55.88 TWh annually. That would be equal to nearly 27% of HQ's 2019 net sales of 208.3 TWh.

HQ claims, as recently as November 2019, HQ that it has 40 TWh of "surplus energy."⁶ It also claims it has a potential to supply 13 TWh of additional energy resulting from future efficiency improvements as well as "a wetter climate by 2050" that could help to serve its domestic and export commitments.⁷ However, any such potential gains would be more than offset by the expected increase in 12.5 TWh of new domestic demand over just the coming decade, 7.8 TWh of which is expected to come from natural growth (rather than any specific initiative).⁸ It should be noted that in 2019, domestic sales reached "an unprecedented 174.6 TWh" with 1.4 TWh of new consumption attributed to higher baseload demand in all market segments.⁹ Thus it appears clear that any additional gains to the existing system would be canceled out over the next decade.

This paper reviews HQ's claims that, due to surplus energy and increased capacity from upgrades, HQ has enough hydroelectricity available to meet the future export requirements of NECEC and CHPE. It evaluates whether it is likely to have to meet such demand by building new dams or by adopting some other strategy, such as reducing existing non-contractual export volumes.

The conclusion is that HQ cannot meet the requirements for the NECEC and CHPE demand solely from existing generation facilities under the existing status quo conditions (including service of existing export volumes). The surplus generating capability and spillage cited by HQ and politicians as being capable of supporting these exports are highly variable and insufficient. Either HQ will have to back down existing export volumes, or build new hydro facilities, or resort to a combination of both strategies. HQ's ongoing construction of new hydropower facilities and its plans for new facilities is in large part driven by HQ's interest in exporting to the U.S. HQ and politicians and official HQ documents have made clear linkages between dam construction efforts and export markets. In fact, exports are a contributing factor to HQ's current build-out of the Romaine Phase 4 project (to be completed by 2021), as well as the potential development of additional and as yet un-named supply resources, which could be new dams, contemplated in the ensuing years.

In other words, HQ's numbers do not add up, leaving open the potential for construction of new dams in the future to meet these additional proposed commitments.

ANALYSIS

Hydro-Quebec is proposing two multi-decadal contracts to sell hydropower to Massachusetts and New York City across two separate designated transmission corridors:¹⁰

New England Clean Energy Connect starts at the Canadian border and goes through Maine to supply 1,200 MW/9.45 TWh to Massachusetts under three contracts with electric distribution utilities (see Footnote 2). It is a project with Central Maine Power (CMP), which is owned by Iberdrola/Avangrid. Regulatory approvals are pending.

Champlain Hudson Power Express starts at the Canadian border and lands in Astoria, New York City, traveling under Lake Champlain, the Hudson, East and Harlem Rivers. The transmission corridor possesses the requisite regulatory approvals although in June 2019, the proponent filed a request to expand the capacity of the line by 250 MW of potentially bi-directional capacity,¹¹ for a total of 1,250 MW (8.3 and potentially up to 10.38 TWh if the 250 MW line were loaded with HQ power at the same ratios as the CHPE line). CHPE is a project of Transmission Developers International (TDI), financed by Blackstone.

From an energy planning and economic modeling perspective, new marginal demand is considered to be met by the next (marginal) supply resource in the planning queue since (all else being equal) that additional new demand drives the need for new supply. Exports are typically considered to be the discretionary demand on the margin, after existing domestic demand requirements have been met. In fact, HQ is committed by law to supply 165 TWh of 'heritage pool' annual energy to meet domestic demand.¹² It defines surplus – which is available for export - to be anything net energy available above that 165 TWh threshold. The human, environmental and economic impacts of hydropower dams have been documented by peer-reviewed research.¹³ Thus, any newly built hydroelectric resources – and their associated impacts - are tied to that marginal demand.

Given that context, and in the particular case of HQ's contemplated exports to the Northeast U.S., the appropriate questions to be asked are:

Is there sufficient energy and generating capacity in HQ's existing system to reliably meet the proposed new export obligations for hydroelectricity associated with NECEC and CHPE, in addition to that already being exported, or do new facilities have to be built? HQ's claim that existing resources are sufficient would seem unlikely, since (if nothing else were to change), that would imply that today the utility has massive and consistent annual system amounts of energy available beyond what it currently sells today (sufficient to support the new and steady volumes associated with firm export contracts). It also implies that those volumes would be available at all times of the year.

Put another way, in the absence of the NECEC and CHPE projects, would construction of any additional facilities, including completion of HQ's Romaine 4 dam, be necessary? The answer to that question is no. While there is some significant quantity of excess energy and additional capacity available beyond existing domestic and export commitments, it is apparent that it varies considerably on an annual basis, and is far from sufficient to consistently support both transmission corridors and associated contracts. The only way to meet the new demand from NECEC and CHPE without new dam construction, would be to back down some level of existing exports to either the U.S. or the Canadian provinces.¹⁴

HQ has consistently asserted that it does not need to construct new hydroelectric facilities to meet the proposed export commitments for NECEC and CHPE. As recently as its November 28, 2019 press release entitled, *Hydro-Québec does not need to construct new hydropower facilities to serve long-term export contracts* HQ specifically states that, "Since 2003, a major build-out has brought new generation capacity totaling 5,000 MW online. Our reservoir levels are at a record high. In the future new supplies of energy can come from the development of wind and energy efficiency and through upgrades at our existing facilities."¹⁵ The utility has asserted that exporting more hydropower to the U.S. via new transmission corridors will not cause any new *marginal impacts* in Canada¹⁶ since the relevant facilities have already been developed, and any related human, social and environmental impacts have therefore already been incurred.

Those assertions are reviewed within the context of recently published and available information,¹⁷ as well as comments by Quebec politicians. While the issue involves numerous complexities,¹⁸ a number of facts relating to this issue are clear:

- (1) The NECEC and CHPE projects will require HQ to export up to 2,450 MW and 19.83 TWh across two proposed transmission corridors that would further tie HQ's system to U.S. markets.**

As shown in Figure 2 below, HQ's 2019 net exports totaled 33.7 TWh (representing 16% of total sales volumes and 22% of net income).¹⁹

In 2019, net exports accounted for 16% of sales volume and generated 22% of the company's net income.

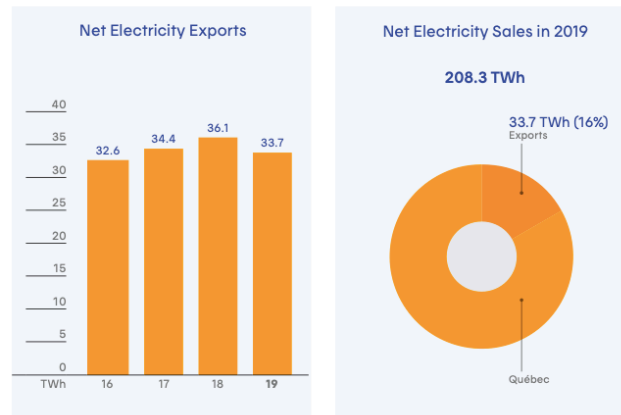


Figure 2: HQ 2019 Exports²⁰

If those exports remain similar (they have stayed fairly steady over the past four years, as illustrated below), and one adds NECEC and CHPE commitments of up to 19.83 TWh, as well as New Brunswick's 2.35 TWh, the sum of these exports would equal 55.88 TWh annually. That would be equal to nearly 27% of HQ's 2019 net sales of 208.3 TWh.

Table 1: Historic Exports and Future Commitments

	Total 2019 Exports	NECEC Corridor	CHPE Corridor	CHPE Proposed Bi-Directional	New Brunswick Exports
Transmission Corridors MW		1,200	1,000	250	
Annual TWh	33.7	9.45	8.3	2.08	2.35

Total 55.88

(2) Each proposed export commitment must be viewed not only in isolation, but also in aggregate, since each has an impact on the whole.

Any single export commitment by HQ, viewed as a single project, could potentially be supplied from the existing facilities, so long as water run-off continues (spillage) to be adequate and domestic demand remains relatively unchanged. However, the fact is that HQ is pursuing three separate projects – NECEC, CHPE and New Brunswick - in addition to the volumes it is already exporting. Thus, NECEC and CHPE must be viewed in the aggregate, since each has an individual impact while adding to the total, and affecting the need for additional generating resources.

(3) Hydro-Quebec continues the ongoing construction of its 245 MW Phase 4 of the 1,550MW/8 TWh Romaine Complex, started in 2016 and scheduled for completion in 2021, delivering over 1 TWh of additional energy into HQ’s system.

In fact, new facilities are currently being constructed today that would contribute to surplus and serve additional demand on the margin which would include NECEC and CHPE. Further, HQ has specifically stated in its two most recent Strategic Plans, (2016-2020²¹ and 2020-2024²²) that it is contemplating additional post-2020 projects that may include additional hydroelectric facilities. Its Strategic Plan specifically states,

“Whether to meet the needs of the Quebec market or to seize export opportunities, we intend to:

> bring into service the last two Romaine generating stations...

> undertake new projects to increase the capacity of some of our hydroelectric generating facilities...

> *determine, by 2020, what our next major hydropower project will be after the Romaine complex.*” (italics added for emphasis).

(4) Hydro-Quebec and Quebec officials have made numerous past claims regarding quantities of spillage that would allow them to serve a significant portion of the export contracts.

While there has been spillage (water currently being released through spillways rather than converted into hydropower in the absence of transmission pathways and markets) in recent years, it has varied quite significantly on an annual basis, and is not a reliable resource for supporting a firm long-term export contract. If one restricts this analysis to the two projects that have contracts or highly interested buyers –NECEC and CHPE – HQ’s marginal capacity and energy requirements for these exports could total as much as 2,450 MW and 19.83 TWh, as noted.

By contrast, HQ’s recently announced spillage numbers fall far below those volumes. HQ spokesmen and Quebec politicians indicate spillage of 4.5 TWh in 2017, and 10.4 TWh in 2018²³ and 12.6 TWh as of May 2019.²⁴ Those numbers and extreme annual variability make it abundantly clear that capturing spillage is unlikely to be anywhere near sufficient to meet new proposed contractual requirements for NECEC and CHPE. Further, available hydroelectric output is greatly affected by issues including inter-annual variation of precipitation, resulting in varying abilities to supply energy, as evidenced by historical charts.²⁵ At times in the past, HQ has run into extreme deficits, which if they were to recur in future decades would make service of the contracts more difficult.

(5) HQ’s hydropower output is also subject to significant seasonal variations, which may also affect its ability to deliver constant supplies of energy.

Cold temperatures affect run-off and quantities of water available for conversion into hydroelectricity. HQ occasionally faces a tight supply situation in the winter, resulting from a combination of decreased

runoff, weather-driven domestic demand, and existing export contracts. HQ deals with this challenge today by maintaining a contract for 500 MW of winter imports from Ontario,²⁶ as well as the implementation of domestic Demand Response programs within the province. This further calls into question the utility's ability to meet the needs of the NECEC and CHPE projects when that energy may be most needed, since cold weather events in Quebec's urban areas often coincide with those along the entire East Coast of North America.²⁷

(6) Either future new supplies of energy to support the proposed export commitments of NECEC and CHPE are either necessary or they are not.

In its November 28, 2019 statement, HQ states “we are able to fulfill both the contracts for Massachusetts along the NECEC line and energy to New York City on CHPE without new build-out of hydropower facilities in Québec,” but then indicates in the same release that, “In the future new supplies of energy can come from the development of wind and energy efficiency and through upgrades at our existing facilities,” thus raising the possibility that energy may not be available in sufficient quantities. However, if any such additional energy resources are necessary for exports, then HQ would be expected to pursue the least cost-resource available to supply the needed quantities of energy. Quebec's recent history shows that wind has not generally been a cost-competitive resource, and HQ has backed out of commitments to significantly more expensive higher cost wind resources, even as it has pressed ahead with construction with Phase 4 of the Romaine Complex.²⁸

In summary, the math is difficult to reconcile and the numbers do not add up. HQ currently claims to have full reservoirs and indicates it is currently spilling water at some times of the year. At the same time, it is serving domestic load *and* 33.7 TWh of annual exports in 2019 to Canadian provinces as well as New England and New York.²⁹ The current difference between its potential ability to supply energy and its existing demand - including both domestic consumption and exports is more or less equal to the amount of the reported spillage volumes (as distinct from the 2019 claim of 40 TWh of surplus). As discussed above, the spillage amount (as reported in various press releases or political statements – HQ has not made this information public) greatly varies from year-to-year.

By 2021, on the supply side HQ will have added 245 MW of capacity and just over 1 TWh of energy from Phase 4 of the Romaine Complex. It may also add some additional capabilities from planned refurbishments of hydro facilities contemplated in its supply plan (Hydro-Quebec claims 13 TWh, although, as noted previously, many of those gains will be offset by increased domestic demand totaling an expected 12.5 TWh by 2029). In addition, HQ plans to supply an additional potential 2,450 MW of capacity and as much as 19.83 TWh of proposed annual energy exports to U.S. markets for NECEC and CHPE *plus* its recent 2020 commitment to export to New Brunswick an average of 2.35 TWh annual from 2020 to 2040. Added to existing exports, new and existing hydropower export volumes total 55.88 TWh.

The total new export demand of 55.88 TWh far exceeds the 40 TWh of annual surplus energy (above the annual 165 TWh “électricité patrimoniale” it is committed to supplying to HQ).³⁰ Even in the best case scenario, if the 13 TWh in claimed system upgrades is added to the 40

TWh in claimed surplus, the total is 53 TWh, still below the needed 55.88. It is important to note that HQ cannot use the upgrades to supply NECEC. ³¹

The only way to meet these new demands is to either (1) build new generating facilities --which are very likely to be hydropower rather than the generally more expensive wind resource -- or (2) to back down the existing non-firm (and less profitable, often spot-market) export volumes to either the Canadian provinces or New England and New York.³² *If the latter occurs, purchasing entities may have difficulty claiming that incremental clean energy goals are being achieved as a result of contractual commitments.*

CONCLUSION

Exports of Hydro-Quebec hydropower available to supply the NECEC and CHPE proposed long-term sales to the Northeast U.S. cannot be served solely from existing generation facilities under the existing status quo conditions (including service of existing export volumes) even with the claimed “surplus” of 40 TWh and potential upgrades of 13 TWh . The surplus generating capability and spillage cited by various officials and politicians as being capable of supporting these exports are highly variable and insufficient to meet the proposed NECEC and CHPE lines. In addition, politicians and both utility officials and documents have made clear linkages between dam construction efforts and export markets.

Without new dams - such as the Romaine dam complex that is under construction – and potential additional future resource additions including adding more hydroelectricity from new dams on Churchill River in Labrador (that are now connected to HQ’s system via a link from the Upper Churchill complex to Muskrat Falls), HQ will be unable to both meet the current and recent export volumes *and* NECEC and CHPE. The proposed export quantities for NECEC and CHPE are simply too significant in the overall context of HQ’s supply and demand mix to be met by marginal resources. Either new hydro generating facilities will have to be built to serve these contract volumes, HQ will have to access additional supplies in other provinces, or it will have to back down recent and existing export volumes, with potential implications for the clean energy strategies of Massachusetts and New York.

Conversely, without new export contracts on top of existing sales volumes, it is highly unlikely that HQ would have the need – or economic opportunity - to continue building new hydro installations or tap new dams outside the province for many years to come. It is therefore inappropriate to describe the capacity and energy required for the new contracts as either “surplus generating capability” or excess “spillage,” and thus not inherently dam-forcing. If all else remains generally equal, the new proposed purchases will eventually create the need for the construction of new hydro facilities, with their associated environmental impacts.

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¹ A terawatt hour is equal to one thousand gigawatt hours or one million megawatt hours.

² In 2019, for the NECEC transmission line, the Massachusetts Department of Public Utilities (DPU) approved contracts, or power purchase agreements (PPA) for three electric distribution companies to buy a total of 9,450,000 megawatt hours of hydropower from Hydro-Quebec. (DPU Dockets 18-64, 18-65, and 18-66). The Massachusetts NECEC contract specifies firm delivery of 1,200 MWs of capacity and 9.455 annual terawatt-hours of energy. All three PPAs call for identical fixed amounts of energy to be delivered for every hour during the year. For example, the contract with National Grid (DPU 18-65) specifies hourly delivery of 498.348 MWh for each hour over the 20-year contract duration. The DPU approval of the three contracts for NECEC is under appeal to the Massachusetts Supreme Judicial Court as of February 2020.

<http://www.chpexpress.com/press-releases/061219.php>

³ http://www.chpexpress.com/pa_analysis.php There is no contract for delivery of HQ power to New York, only a proposed transmission corridor. The CHPE proposal would involve a minimum of 1,000 MW and 8.3 TWh, with an additional 250 proposed bi-directional extension. In theory, that 250 MW of additional transmission capacity could be fully loaded with HQ energy year-round if the economics were favorable. There appears to be no language currently in place that would prohibit such utilization. That could potentially increase the net energy imported to the U.S. by as much as another 2.08 TWh depending on how it is utilized.

⁴ <https://news.hydroquebec.com/en/press-releases/1574/hydro-quebec-and-nb-power-sign-agreements-on-electricity-purchases-and-expertise-sharing/>

⁵ <http://www.hydroquebec.com/data/documents-donnees/pdf/annual-report.pdf>

⁶ <http://www.hydroquebec.com/data/achats-electricite-quebec/pdf/portrait-ressources-energetiques.pdf>

⁷ <https://resources.unsdsn.org/deep-decarbonization-in-the-northeast-united-states-and-expanded-coordination-with-hydro-quebec> In its April 2018 document, *Deep Decarbonization in the Northeastern United States and Expanded Coordination with Hydro-Quebec*, HQ indicates that “current dispatchable hydro is 144 TWh,” but postulates a potential larger supply number of 157 TWh. This would require “no new impoundments but instead comes from efficiency improvements and a wetter climate by 2050.”

⁸ <http://www.hydroquebec.com/data/achats-electricite-quebec/pdf/portrait-ressources-energetiques.pdf>

⁹ <http://www.hydroquebec.com/data/documents-donnees/pdf/annual-report.pdf>

¹⁰ Two additional potential corridors exist: the permitted 1,000 MW/8.3 TWh New England Clean Power Link (NECPL) that would connect to Massachusetts via Vermont <http://www.necplink.com>; and the 1,200 MW/9.99 TWh Granite State Power Link that would traverse New Hampshire into Massachusetts. If the NECEC line is built, it would be highly unlikely for either of NECPL or Granite State to proceed in the foreseeable future, given the large quantity of energy Massachusetts would be receiving from HQ. In 2019, Eversource withdrew its application for the Northern Pass hydropower corridor through New Hampshire’s White Mountains after years of opposition and legal challenges. Had this corridor gone ahead, HQ would have committed to export approximately 1,100 MW.

¹¹ <http://www.chpexpress.com/press-releases/061219.php>

¹² <http://www.hydroquebec.com/data/achats-electricite-quebec/pdf/portrait-ressources-energetiques.pdf> This set-aside is known as “bloc d’électricité patrimoniale,” and was established in 2000.

¹³*Sustainable hydropower in the 21st Century*, Moran et al., September 5, 2018, Proceedings of the National Academy of Sciences, <https://www.pnas.org/content/115/47/11891>. The specific human, economic and environmental impacts are affected by a wide range of variables are beyond the scope of this paper. However, it is safe to say that there are documented negative externalities associated with hydroelectric facilities in eastern Canada.

¹⁴ This conclusion is consistent with an independently prepared analysis released in January 2020 by consulting firm Energyzt in its review of the CHPE project entitled “*Understanding the True Impacts of the Champlain Hudson Power Express*.” It concludes “The only way Hydro-Québec could export 8.3 TWh to New York City via CHPE would be to redirect energy sales from other parts of New York, divert energy sales from existing export markets, and/or increase imports into Quebec from other markets, which would then be sold at above-market prices via CHPE.” A 2018 report by Energyzt, *Greenwashing and Carbon Emissions, Understanding the True Impacts of NECEC*” for the Natural Resources Council of Maine and Sierra Club reaches the same conclusion: that HQ does not have the existing capacity to meet the export demands of the firm Massachusetts contract, and notes (page 17) that HQ cannot use power from system upgrades to supply NECEC. See, Section 2.3.

¹⁵ <http://news.hydroquebec.com/en/news/220/hydro-quebec-does-not-need-to-construct-new-hydropower-facilities-to-serve-long-term-export-contracts-riverkeeper-chpe/>

¹⁶ The three Massachusetts contracts describe facilities resources that will supply the contracts: “Hydro-Québec Power Resources’ shall mean, collectively, those existing hydroelectric generating stations, located in the Province of Québec and owned and operated as a system by Hydro-Québec or its subsidiaries from time to time, that produce electric energy.” Exhibit A of the contracts states the HQ facilities used to supply the contracts “shall include the following facilities as of the Effective Date.” See also, DPU Decision, June 25, 2019, p.45 stating, “Exhibit A, [which] identifies each of the 62 hydroelectric facilities that make up the Hydro-Quebec Power Resources.” The statement in Exhibit A that the Hydro-Quebec Power Resources “shall include” the 62 facilities does not limit HQ to these. The discrepancy between the DPU decision and Exhibit A would appear to allow HQ to add new facilities to the list should they become available. Exhibit A includes three of HQ’s four new Romaine hydro generating facilities that have come on line in 2014, 2015 and 2017. It does not include the fourth Romaine dam, scheduled to come on line in 2021. Exhibit A to the contracts excludes the Upper Churchill Falls facility in the Province of Newfoundland and Labrador partially owned by HQ. HQ has been using most of the output of this facility (5,428 MW) since 1971 and has the exclusive right to continue using it until 2041. The Massachusetts contracts require that HQ’s energy be tracked by New England Power Pool, www.nepool.com, by Geographic Information System (GIS) to tie specific export volumes to specific facilities and each facilities greenhouse gas emissions, so they can be tracked by Massachusetts Department of Environmental Protection for purposes of the Global Warming Solutions Act. June 25, 2019, DPU Decision, p. 57. Nonetheless, that does not, by itself, mean that the exports to Massachusetts would not have a potential impact on resources outside of the province but that are nonetheless connected to the system. Electrons cannot be tagged. A power grid is very much like a bathtub: the molecules of water drawn from the tub cannot be directly tracked from origin to end-use. If water is withdrawn from the tub, additional water molecules can be used to refill the tub regardless of their origin. So it is with electricity – which travels at the speed of light. In this sense, the energy supplied by HQ to meet the Massachusetts contracts could come from its own system. However, additional volumetric requirements could also be met by the 5,428 MW Upper Churchill Falls facility in Labrador that is connected to HQ’s system and committed by contract to HQ through 2041. Some energy could also theoretically come from the newly constructed 824 MW Lower Churchill Falls (Phase 1) Muskrat Falls hydroelectric facility in Labrador owned by Nalcor Energy, by virtue of a recently built 500 MW transmission link connecting the facility to the Upper Churchill Falls facility, which in turn is linked to HQ’s network *if a contract were to call for a delivery of power by Nalcor to HQ*. This is especially the case since a portion of the newly constructed Muskrat Falls facility is surplus to the current needs of Newfoundland and Labrador. Unless *every one* of HQ’s hydroelectric facility volumes were specifically tied to serving identified loads, both within the province of Quebec as well as to export markets, the source of additional supply is, in fact, highly fungible.

¹⁷ Unlike many other North American utilities and power grids, detailed and relevant HQ documentation is often difficult to access (either in French or English), with much of the information only available at an aggregate level, making detailed analysis somewhat challenging. For example, there is no available information regarding planned specific hydroelectric resource developments beyond 2021, although there have been indirect references made to identifying future such resources. HQ's 2020-2024 Strategic Plan is one such example of the superficial documentation available. (<https://issuu.com/hydroquebec/docs/2019g252a.secure?fr=sNTIyYzI3OTk3MQ>). Unlike typical Integrated Resource Planning documents put out by many utilities with time horizons as long as a decade or more, the four-year plan does not identify a single specific supply resource (beyond two experimental solar facilities). It commits only to "Decide on future renewable energy projects...taking into consideration the various renewable options available (e.g., hydroelectricity, solar power, and wind power) as well as demand response solutions." Given the long lead times necessary for construction and interconnection of many of these resources, the documentation is insufficient.

¹⁸ These complexities involve, at a minimum: the continuation of (or variance from) existing export arrangements with other provinces, as well as New York and New England, and other areas of the northeastern U.S.; overall installed capacity on HQ's system; annual and seasonal precipitation levels in Quebec and Labrador (since the 5,428 MW Upper Churchill Falls Complex feeds directly into HQ's system as shown in Figure 1); Quebec's domestic and seasonal (especially winter) demands; the possible extension or termination of an existing 500 MW seasonal winter import arrangement with Ontario; the future success of Quebec's planned electrified transportation and domestic energy efficiency initiatives; and the growth of Quebec's economy.

¹⁹ <http://www.hydroquebec.com/data/documents-donnees/pdf/annual-report.pdf>

²⁰ <http://www.hydroquebec.com/data/documents-donnees/pdf/annual-report.pdf>

²¹ <http://www.hydroquebec.com/data/documents-donnees/pdf/strategic-plan-2016-2020.pdf> The 2016-2020 Plan (page 9) specifically indicates HQ will "determine, by 2020, what our next major hydropower project will be after the Romaine complex."

²² <http://www.hydroquebec.com/data/documents-donnees/pdf/strategic-plan.pdf?v=2019-12-05> The 2020-2024 Plan (page 34) indicates that HQ will "Decide on future renewable energy projects to meet long-term clean power needs, taking into consideration the various renewable options available (e.g., hydroelectricity, solar power and wind power) as well as demand response solutions."

²³ <https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/10503019>

²⁴ <https://montrealgazette.com/news/quebec/francois-legault-presents-electric-vision-of-quebecs-green-future> Prime Minister Legault cited the 12.6 TWh number during a speech (though the Montreal Gazette appears to have mistakenly referred to it as "TW," rather than TWh).

²⁵ <https://adaptationcanada2016.ca/wp-content/uploads/2016/04/W4A-Guay.pdf>

²⁶ <http://www.hydroquebec.com/international/en/exports/markets/ontario.html>. That 500 MW of capacity would largely be supplied by gas-fired generation that sits on the margin in the Ontario system. For its part, Ontario purchases 2 TWh annually during the other months in part to offset natural gas and associated carbon emissions.

²⁷ One possible option would be to back down other existing exports under non-firm contracts, although this may not meet the need for 'incrementality' unless the energy shortfall is remedied during other periods.

²⁸ Hydro-Quebec does not publish an Integrated Resource Plan, per se, nor does it have a competitive power market with publicly available prices, so it is hard to determine the exact costs of various resources in the development stack. A 2018 Toronto Globe and Mail piece (<https://www.theglobeandmail.com/business/commentary/article-is-wind-power-blowing-holes-in-hydro-quebecs-profits/>) addressing HQ's plan to back out of a proposed 200 MW wind project indicates that HQ's CEO estimated potential losses of \$1.5 to \$2.5 bn CDN over the 25-years of the proposed project. The Globe and Mail compared the \$.10 per kWh of that wind project to \$.029 per kWh of legacy hydro facilities and \$.065 for the Romaine project. Thus, at present, it appears based on that evidence that hydropower would be considerably less costly than development of new wind projects, although for both resources such associated costs are highly site- and project-specific.

²⁹ <http://www.hydroquebec.com/generation/centrale-construction.html> While some additional capacity and energy may be achieved from upgrades, HQ's documents suggest that there are only a small number of sites under study, under construction, or being rehabilitated. As noted in Entergy's 2020 report, "...those reported upgrades are already required to maintain exports at historical levels while meeting Quebec's domestic load growth. Those upgrades only offer 13 TWh of additional energy, all of which is required to meet Hydro-Quebec's growing demand. Hydro-Quebec does not intend to supply CHPE through upgrades." P. 30, Section 34.2. As yet, there does not appear to be a clear successor to Phase 4 of the Romaine Complex.

³⁰ According to HQ's website addressing its current exports, these existing contractual commitments include a commitment to deliver 2 TWh to Ontario through 2023; .6 TWh to the municipality of Cornwall, Ontario (end date unspecified); and 1.3 TWh to Vermont through 2038. The document also mentions a long-term contact in which HQ "commits to supplying 900 MW of capacity to the NYISO for 20 years (2010 through 2030)," but it does not specify the amounts of energy to be delivered. <http://www.hydroquebec.com/international/en/exports/> It is worth noting that the three Massachusetts contracts commit HQ to supplying hydropower only – not wind – from specific designated hydro facilities.

³¹ Central Maine Power, Request for Approval of CPCN for the New England Clean Energy Connect, Maine P.U.C. No. 2017-000232, Rebuttal Report of Dickinson, *et al.*, July 13, 2018, pp. 30-35 cited in Entergy's 2018 Report footnote 39.

³² A similar, independently prepared analysis released in January of 2020 comes to a similar conclusion, stating "If both NECEC and CHPE proceed...Hydro- Québec would have less than 5 TWh available each year to sell across existing lines that historically have transmitted up to 36.5 TWh per year. Hydro-Québec would have difficulty meeting its CHPE contractual obligations during a dry spell or in periods with less than average water conditions; Hydro-Québec would have to purchase energy from other markets." The paper also states "The only way Hydro-Québec could export 8.3 TWh to New York City via CHPE would be to redirect energy sales from other parts of New York, divert energy sales from existing export markets, and/or increase imports into Quebec from other markets..." https://www.ippny.org/vs-uploads/chpe-study/1580134557_ENERGYZT%20REPORT%20-%20CHPE%20Impacts_01272020_FINAL.pdf