Hydro-Québec's Projected Demand and Supply

Final Presentation

16 May 2022

Contents

Objective: Summarize Hydro-Québec's projected portfolio of generation supply and energy purchases under alternative conditions

Contents:

- Methodology
- Demand
- Supply
- Supply/Demand Gap
- Economic Build-out
- Conclusions

Appendix A: Assumptions

Hydro-Québec's future supply resources depend on future demand and exports

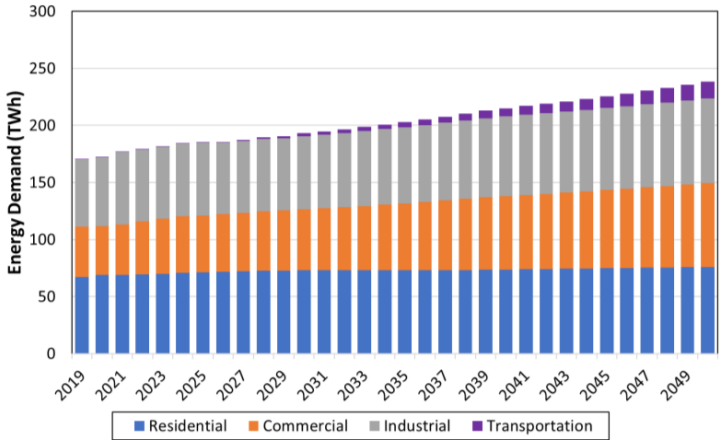
Hydro-Québec's Projected Demand and Supply

METHODOLOGY

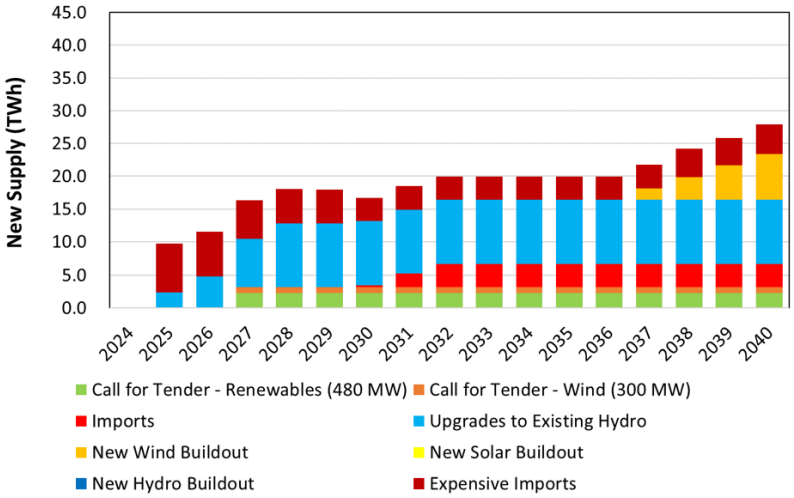
Methodology

Objective of analysis is to understand Hydro-Québec's future

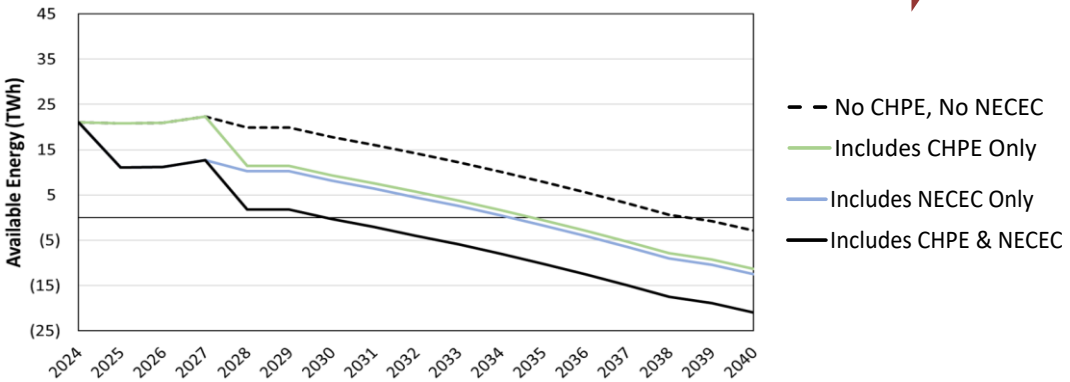
Future Load



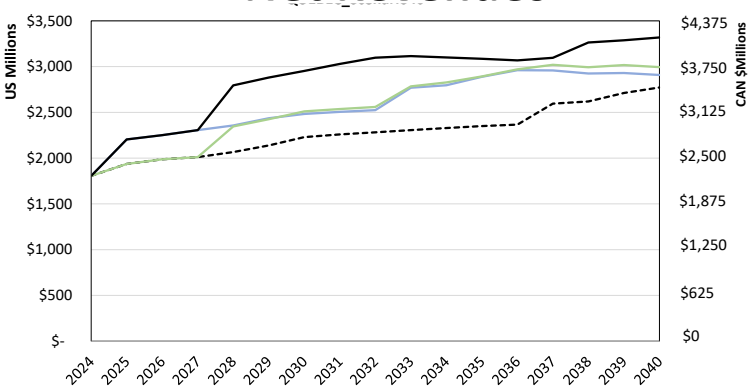
Build-Out/Purchases



Existing Supply/Shortfalls



Net Revenues



This approach is consistent with economics and Hydro-Québec's stated strategy

Methodology

Build a capacity planning model to arbitrage supply and demand

Approach

- **STEP 1:** Project demand and existing contractual obligations for each year
- **STEP 2:** Project supply based on existing and anticipated procurements
- **STEP 3:** Compare demand to existing supply for each year
- **STEP 4:** Allocate any excess energy *in each year* to export markets from highest to lowest hourly price
- **STEP 5:** Increase spot imports and build-out supply, if economic, to fill the gap between supply and demand and to arbitrage import and export opportunities
- **STEP 6:** Apply average prices/rates to demand components to calculate gross revenues and subtract existing import/build-out costs to get net revenues for the entire portfolio

This approach is consistent with economics and Hydro-Québec's arbitrage strategy

ENERGYZT

Methodology

Hydro-Québec has four business segments that house 11 groups

Corporate and Administrative Services

Generation

- Innovation, production, santé, sécurité et environnement
- Legacy pool supply
- Power generation development
- System firming and balancing
- Exports and imports
- Arbitrage transactions

Transmission

- TransÉnergie et équipment
- Transmission System Management
- System Security
- Power flows
- Interconnections

Distribution

- Distribution, approvisionnement et services partagés
- Low-voltage delivery services
- Operation and development
- Retail electricity sales
- Customer services
- Promotion of energy efficiency

Construction

- Design
- Execution
- Construction
- Refurbishment
- Primarily generation and transmission facilities

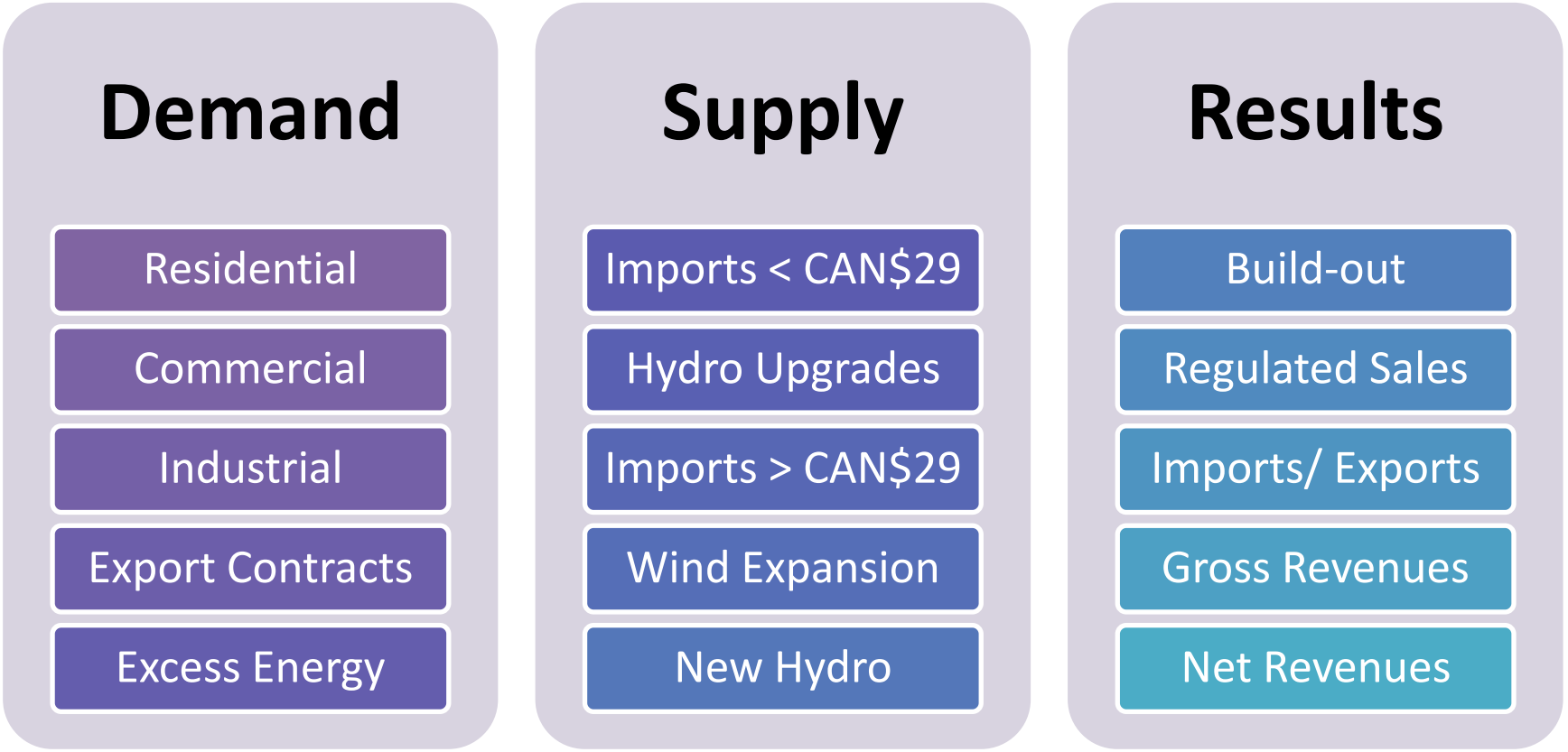
Source: Hydro-Québec Annual Report, 2021

Assume Hydro-Québec is economically rationale and optimizes across all segments

Methodology

Initial calculation compares projected demand to supply

Model Overview



The model operates a capacity planning model with economic build-out rules

Methodology

Scenarios provide insights into how Hydro-Québec may act and why

Alternative Scenarios

Demand

- **D0:** 2020 load + contracts
- **D1:** CER1
- **D2:** CER2
- **D3:** HQD/CER1
- **D4:** HQD/CER2

Canada Energy Regulator provides two scenarios:

CER1 = Current

CER2 = Evolving

5

x

New Exports

- **Case 1:** No new lines
- **Case 2:** CHPE only
- **Case 3:** NECEC only
- **Case 4:** Both CHPE and NECEC

Each demand projection runs all cases for comparison

4

x

Build-out

- Build or buy according to economics
- Assume low-cost imports up to the marginal cost of hydroelectric upgrades
- Between hydroelectric upgrades and wind, include add wind and new hydro if economic

1

This presentation highlights build-out under a subset of illustrative scenarios

Methodology

Scenario results are used to estimate gross and net revenues

Net Revenue Calculation

Gross Revenues

- Existing revenues plus revenues for incremental growth at existing rates
- Incremental demand projections by ratepayer group/export obligations
- New load growth multiplied by existing regulated rates/contract prices

Incremental Costs

- Incremental supply costs based on levelized cost estimates
- Levelized cost ($/MWh) multiplied by MWh generated by new supply
- Import costs equal price in other markets plus carbon adjusted for losses

Net Revenues

- Existing net revenues
- Plus net revenues for incremental load/exports (Gross Revenues less Costs)

Revenues indicate whether existing rates are sufficient given incremental costs

Hydro-Québec's Projected Demand and Supply

DEMAND

Demand

A variety of sources can be used to develop load projections

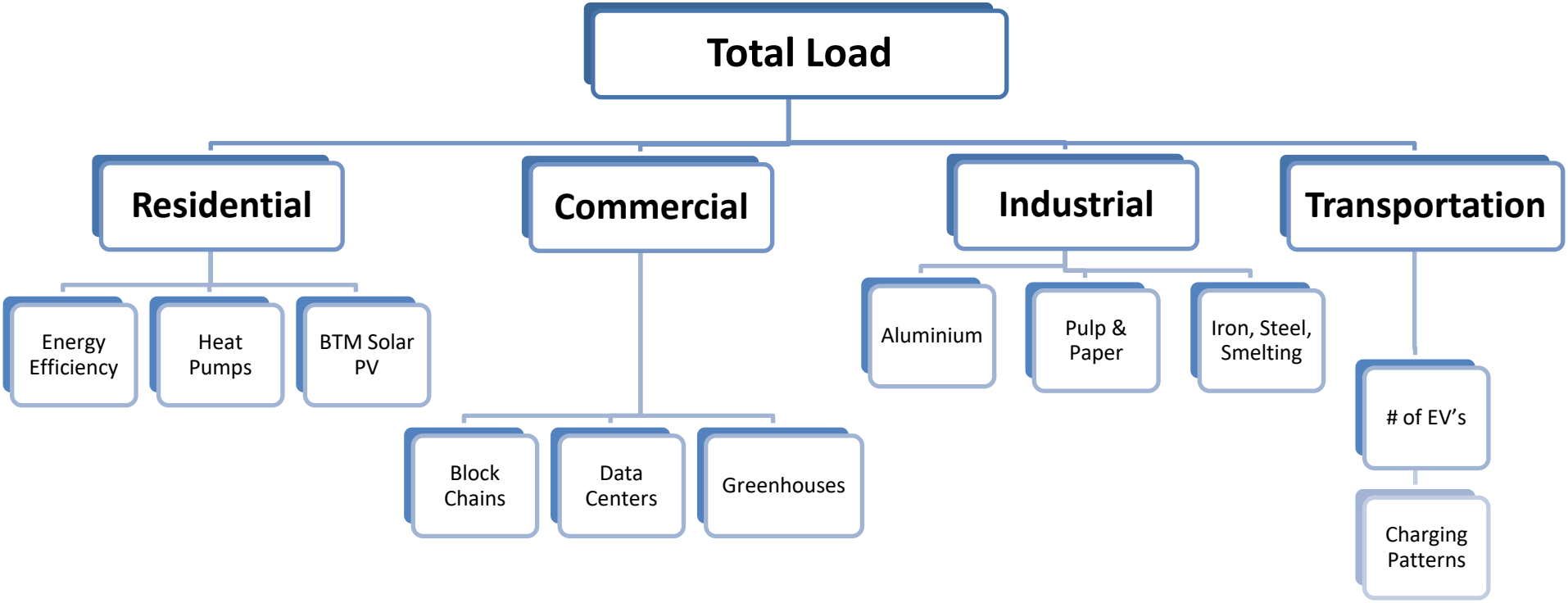
Projections Used in Developing Load Growth Projections

HQD	Historical Data	• Provides a starting point for projections • Can also be used to analyze historical trends and apply to near-term growth
HQD	Hydro-Quebec "2019-29 Energy Supply Plan"	• 2019-2029 annual Energy Supply Plan • Annual updates are provided, offering growth estimates by sector and sub-sectors through 2029 • Estimates can be used to develop near and long-term growth projections
CER	Canada Energy Regulator "Canada's Energy Future"	• Annual projections to 2050 provided yearly, offering insight by sector and fuel source • Includes current and evolving scenario policies • Data can be used to develop future growth rates
	EIA "Annual Energy Outlook"	• Annual projections to 2050 provided yearly, offering insight by sector and fuel source, among other thing • Data includes various scenarios but is limited to the U.S. • Trends in regions similar to Québec can be used to develop growth assumptions such as transportation
	Market Research	• Additional market research on specific sectors and sub-sectors • Findings can be used to develop growth assumptions, both near and long-term
	Quebec's Announced Goals	• Future goals must be factored into growth assumptions to ensure goals are met • Includes areas like energy efficiency, heat pumps, electric vehicles, emissions, etc.

Energyzt reviewed the alternatives and adopted the HQD and CER projections

HQD demand projections build-up from annual projections by sector

Primary Factors Impacting Québec Load through 2050



A number of growth assumptions can impact total load, especially after 2030

ENERGYZT

Demand

In HQD's projections, new industries drive growth

Hydro-Quebec
Electrical Energy Demand Projections

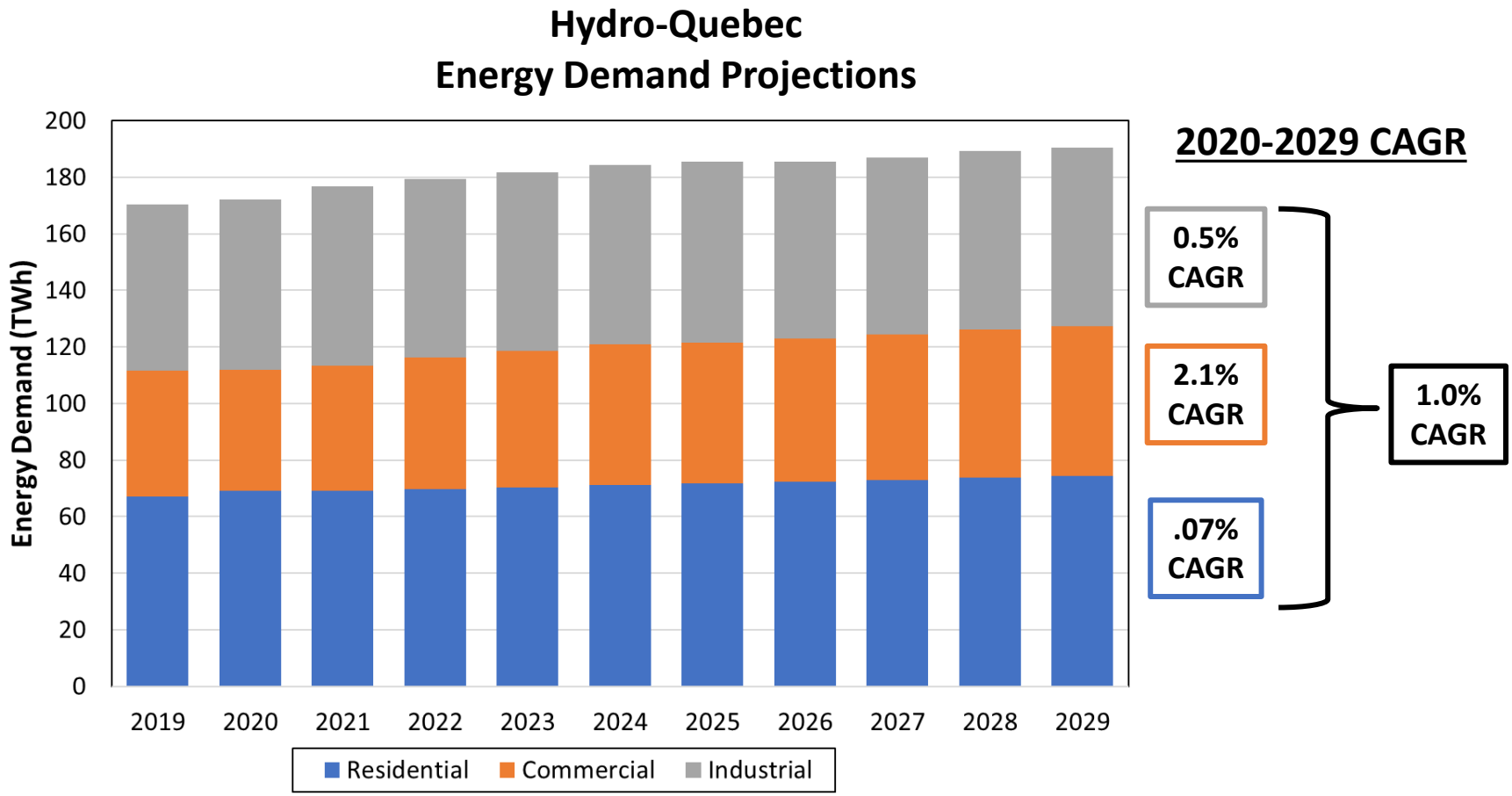
Load Category	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	CAGR
Residential	67.2	69.1	69.0	69.8	70.4	71.3	71.6	72.4	73.0	73.9	74.3	0.7%
Commercial	44.4	42.9	44.2	46.5	48.2	49.5	50.0	50.6	51.3	52.3	53.0	2.1%
Commerical & Institutional	38.9	37.4	38.5	40.6	41.9	43.0	43.6	44.3	45.1	46.0	46.8	2.3%
(Implied) General Commerical & Institutional	37.3	35.7	36.6	38.2	38.5	39.9	39.2	39.3	39.7	40.2	40.6	1.3%
Block Chains	0.7	0.6	0.7	0.9	1.2	1.2	1.1	1.1	1.0	0.9	0.9	4.1%
Data Centers	0.6	0.7	0.7	0.9	1.3	1.8	2.3	2.8	3.3	3.8	4.2	19.6%
Greenhouses	0.3	0.4	0.5	0.6	0.9	0.1	1.0	1.1	1.1	1.1	1.1	10.6%
Municipal Networks & Public Lighting	5.5	5.6	5.7	5.9	6.3	6.5	6.4	6.3	6.3	6.2	6.2	1.0%
(Implied) General Municipal Networks & Public Lighting	5.2	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.3	5.2	5.3	0.4%
Block Chains	0.3	0.5	0.6	0.8	1.2	1.3	1.2	1.1	1.0	1.0	0.9	6.1%
Industrial	58.8	60.1	63.7	63.2	63.2	63.5	63.8	62.4	62.7	63.2	63.1	0.5%
Industrial SME	8.4	8.0	8.1	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.0	0.0%
Industrial Large Companies	50.4	52.1	55.6	55.1	55.1	55.4	55.7	54.3	54.7	55.1	55.1	0.6%
Aluminium Smelters	18.7	23.8	25.6	24.9	25.0	25.1	25.1	23.4	23.4	23.5	23.4	-0.2%
Pulp & Paper	12.0	9.9	10.0	9.9	9.6	9.5	9.4	9.3	9.2	9.1	9.0	-0.9%
Oil & Chemicals	4.8	4.3	4.7	4.6	4.6	4.7	4.9	5.0	5.1	5.3	5.3	2.1%
Mining	4.2	3.9	4.1	4.4	4.6	4.8	5.0	5.3	5.5	5.8	5.9	4.2%
Iron & Steel, Smelting & Refining	7.0	6.6	7.4	7.4	7.4	7.4	7.4	7.5	7.5	7.5	7.5	1.3%
Other Large Industrial Companies	3.8	3.6	3.8	3.8	3.8	3.9	3.9	3.9	3.9	4.0	4.0	1.1%
Regular Sales in Quebec	**170.4**	**172.1**	**176.9**	**179.5**	**181.8**	**184.3**	**185.4**	**185.4**	**187.1**	**189.3**	**190.4**	**1.0%**
Regular Sales in Quebec with Losses	**182.9**	**184.6**	**190.3**	**192.9**	**195.3**	**198.0**	**199.1**	**199.2**	**201.0**	**203.6**	**204.7**	**1.0%**

Source: Hydro-Québec Electricity Supply Plan, 2021 Update.
https://www.hydroquebec.com/electricity-purchases-quebec/supply-plan.html#:~:text=Hydro-Qu%C3%A9bec%20publishes%20every%20three%20years%20an%20Electricity%20Supply,is%20reviewed%20annually%20by%20the%20R%C3%A9gie%20de%20l%E2%80%99%C3%A9nergie.

Hydro-Québec load projections historically have overstated actual load growth

Demand

HQD's annual forecasts provide near-term projections by customer type



Hydro-Québec Electricity Supply Plan, 2021 Update.
https://www.hydroquebec.com/electricity-purchases-quebec/supply-plan.html#:~:text=Hydro-Qu%C3%A9bec%20publishes%20every%20three%20years%20an%20Electricity%20Supply,is%20reviewed%20annually%20by%20the%20R%C3%A9gie%20de%20l%E2%80%99%C3%A9nergie.

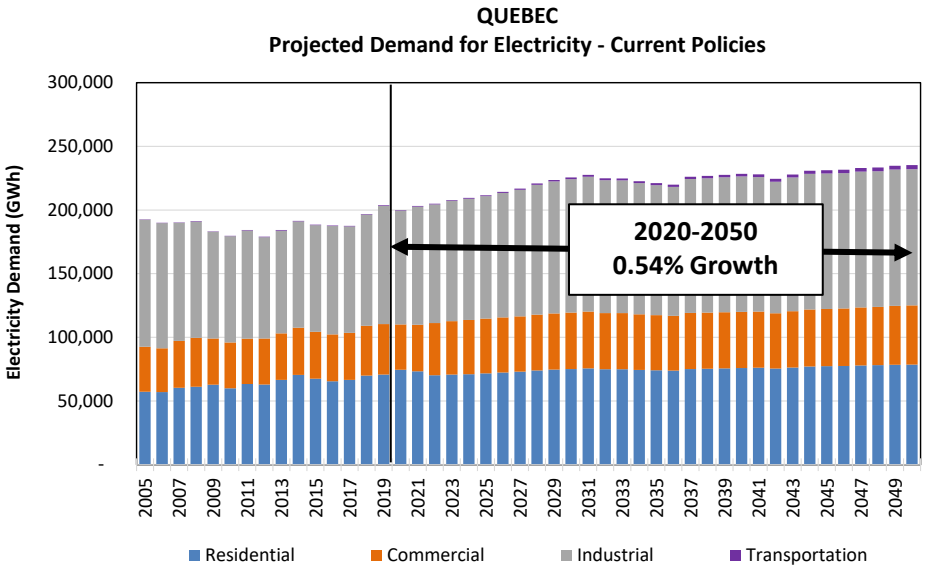
Hydro-Québec projects a 20 TWh increase in demand over 10 years (~1% per year)

Demand

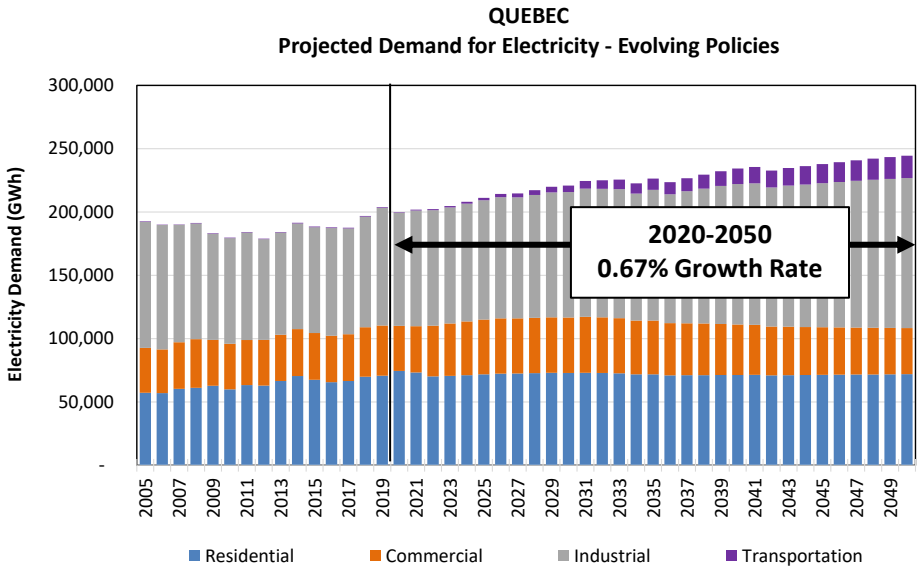
The Canada Energy Regulator (CER) also provides long-term projections

Québec 2021 Energy Projections

Current Policies



Evolving Policies



Under CER's projections, HQ requires less in the near-term but up to 45 TWh by 2050

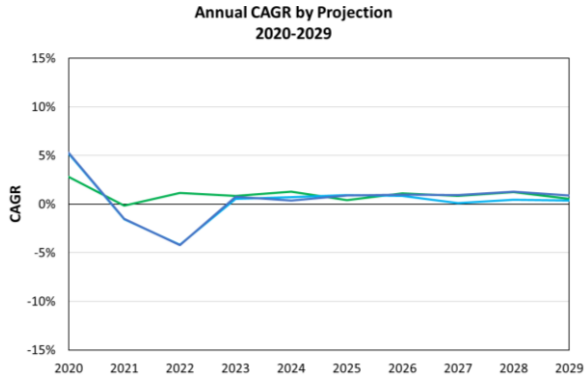
Source: Canada Energy Regulator, https://apps.cer-rec.gc.ca/ftrppndc/dflt.aspx?GoCTemplateCulture=en-CA

Evolving policies increase electric vehicle load and demand side management

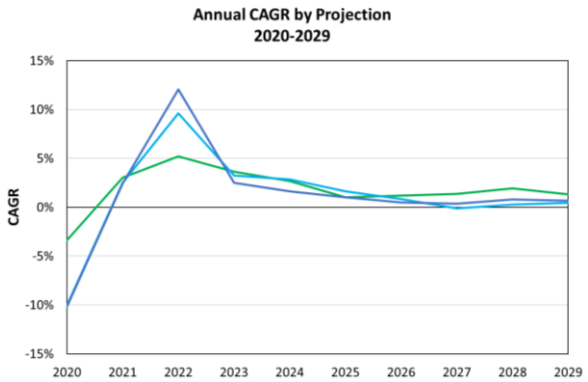
Demand

Projected growth rates vary by sector and by source of projected load

Residential Sector

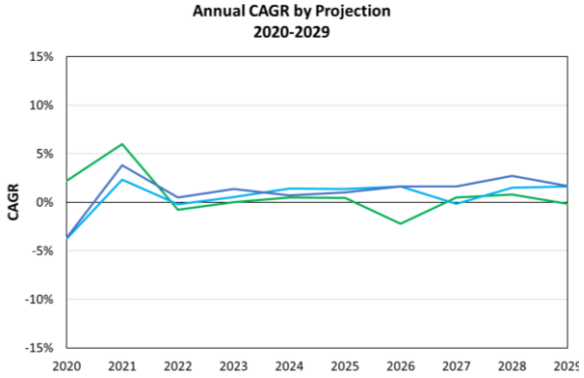


Commercial Sector

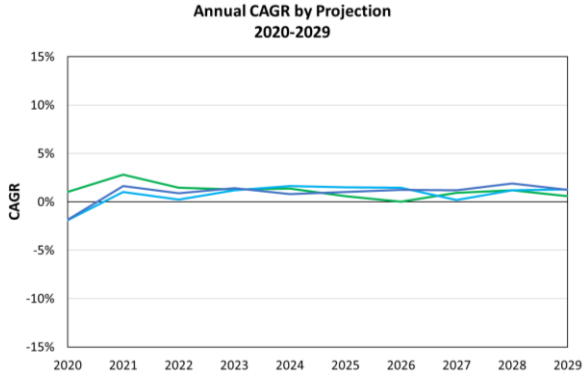


HQ Evolving Current

Industrial Sector



All Sectors



Over time, projected growth rates converge to be consistent with inflation

ENERGYZT

Demand

Combining the CER and HQ projections create four load growth scenarios

Projected Load Growth Assumptions

Scenario	2020 Start*	2021 - 2029	2030 - 2050	2050 Load**
Scenario 1	172.2 TWh	CER - Current	CER – Current*	203 TWh
Scenario 2	172.2 TWh	CER – Evolving	CER – Evolving	213 TWh
Scenario 3	172.2 TWh	HQ Plan	CER – Current*	222 TWh
Scenario 4	172.2 TWh	HQ Plan	CER - Evolving	238 TWh

* Demand Growth for electric vehicles is held equal to the CER-Evolving scenario given recent Quebec policy announcements

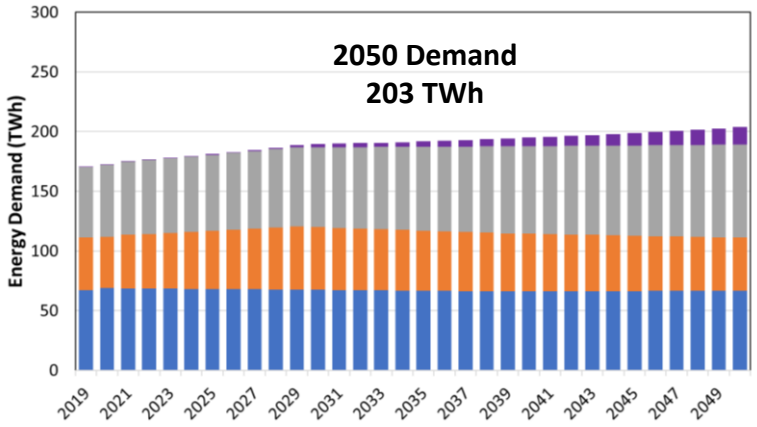
** Load starting and end points do not account for losses that need to be generated to bring energy to load; losses are included in the model

These four scenarios bracket future growth based on public projections

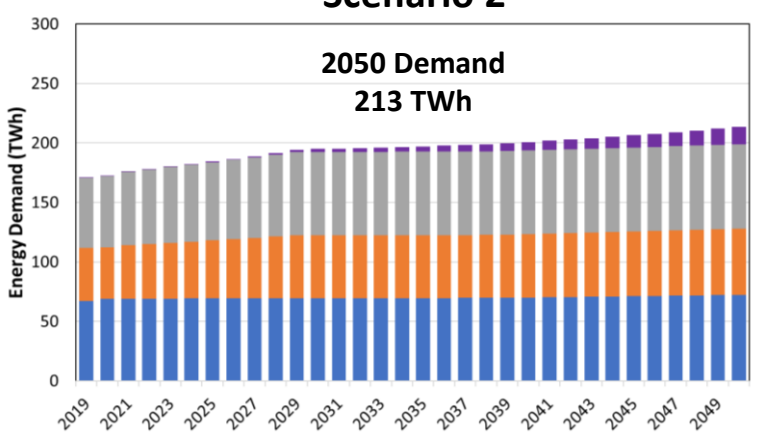
Demand

Varying load growth assumptions result in a difference of 35 TWh by 2050

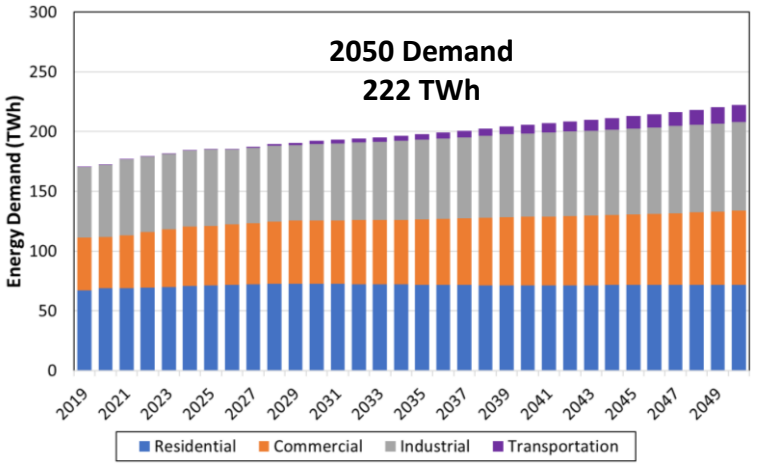
Scenario 1



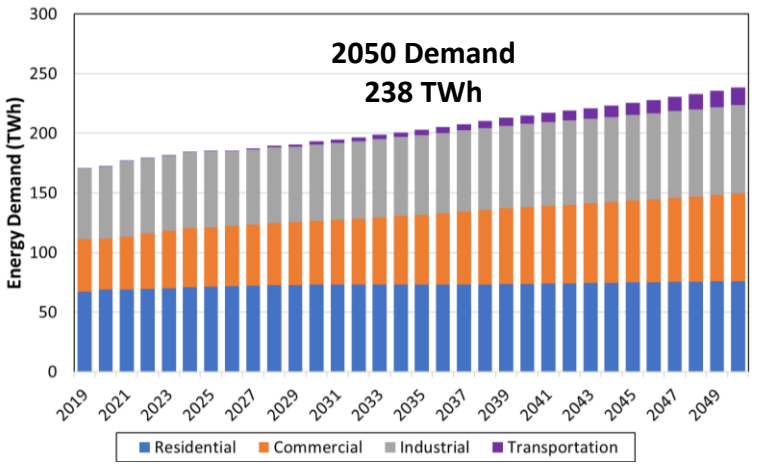
Scenario 2



Scenario 3



Scenario 4



The CER projections tend to have lower growth rates than HQ's projections

* Demand Growth for electric vehicles is held equal to the CER-Evolving scenario given recent Quebec policy announcements

Hydro-Québec's Projected Demand and Supply

SUPPLY

Hydro-Québec has access to alternative resources to meet projected load

Hydro-Québec Alternatives for Meeting Supply Requirements

HQ Distribution

Wholesale Purchases

Purchases from other Markets

Procurement from IPPs

Procurement from HQ Power

Retail

Smart Power Use by End-Users

Energy Efficiency and Demand Response

HQ Power

Wholesale Purchases/Sales

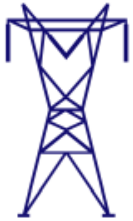
Upgrades or New Builds

Sales to other Markets

Reduction in Exports

TranÉnergie

Delivery



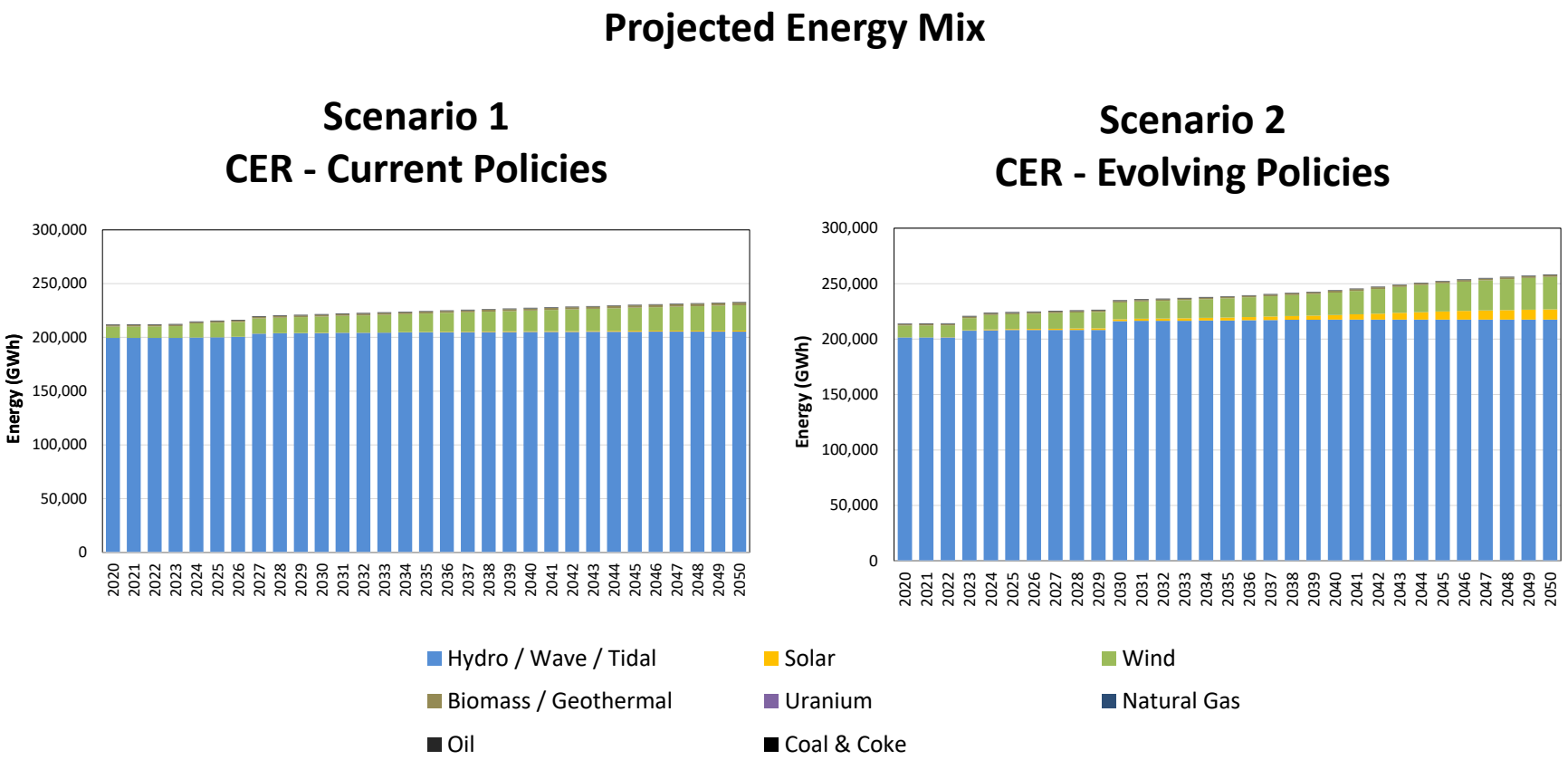
New Transmission

New Interties

Energy efficiency is included in Hydro-Quebec's and CER's demand projections

Supply

CER projections illustrate how the associated energy mix can vary

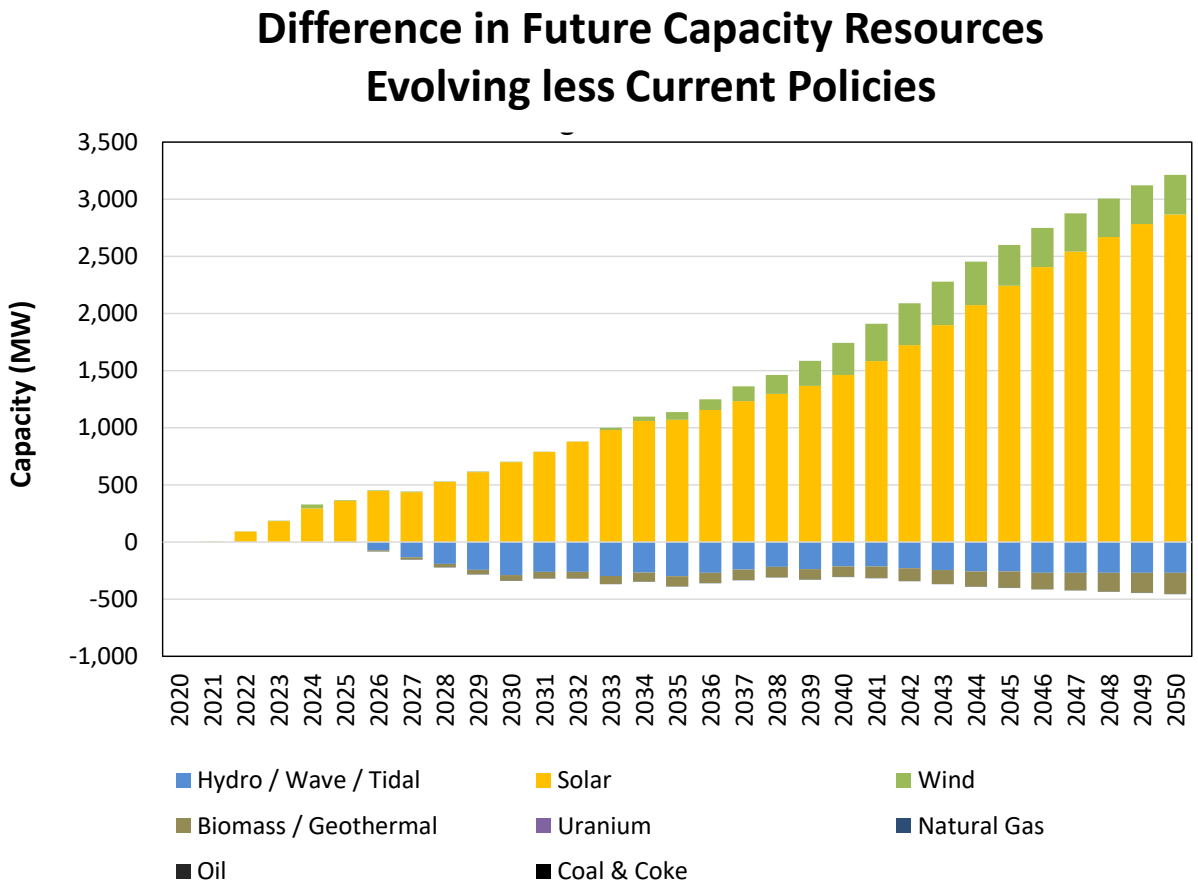


Source: Energyzt analysis of Canada Energy Regulator, https://apps.cer-rec.gc.ca/ftrppndc/dflt.aspx?GoCTemplateCulture=en-CA

However, CER assumes that Québec builds only solar or wind to meet load growth

Supply

CER's evolving scenario build wind and solar versus hydroelectric dams



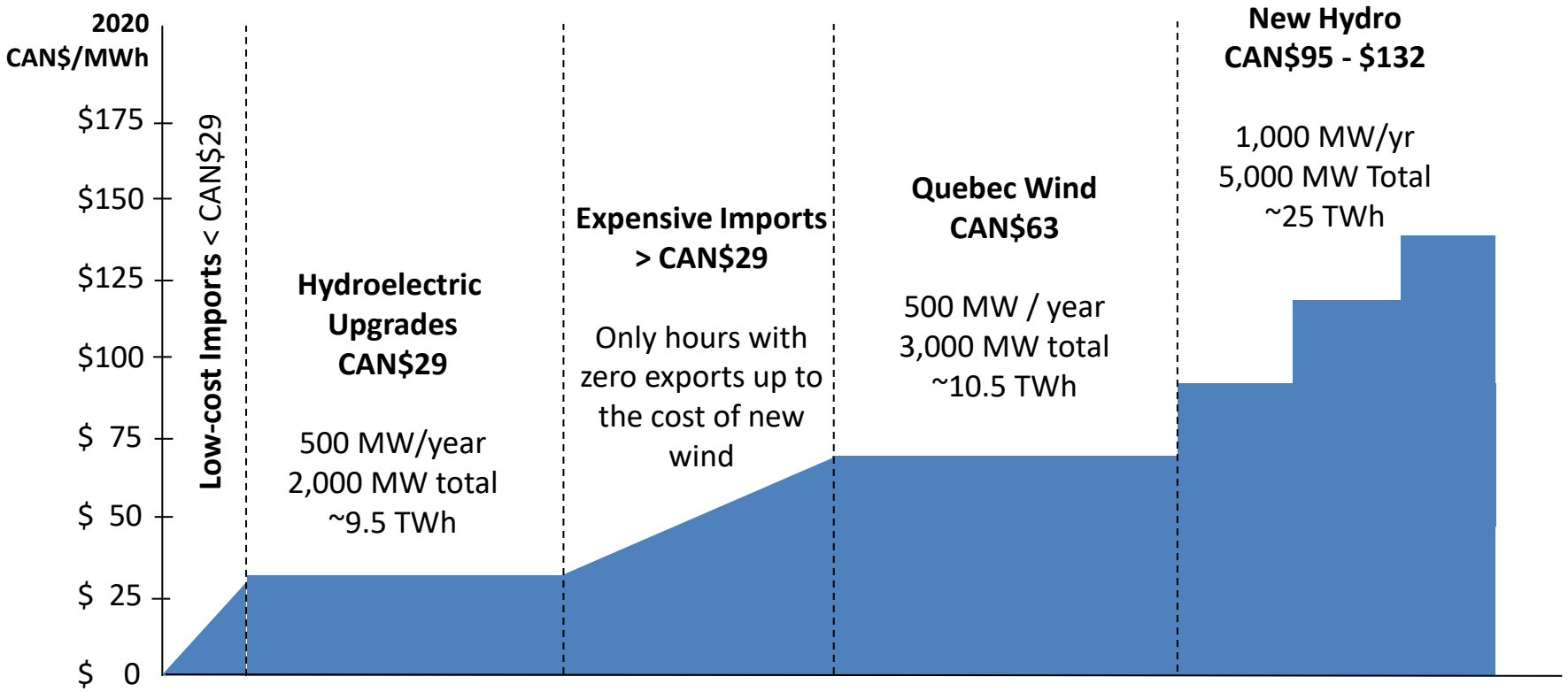
Source: Energyzt analysis of Canada Energy Regulator, https://apps.cer-rec.gc.ca/ftrppndc/dflt.aspx?GoCTemplateCulture=en-CA

An alternative approach would examine the most economic build-out options

Supply

The adopted build-out rule is economic options subject to constraints

Illustration of Supply Build-out Constraints



Energyzt's analysis builds or buys from external markets according to economics

Supply

Carbon costs and line losses make imports more expensive

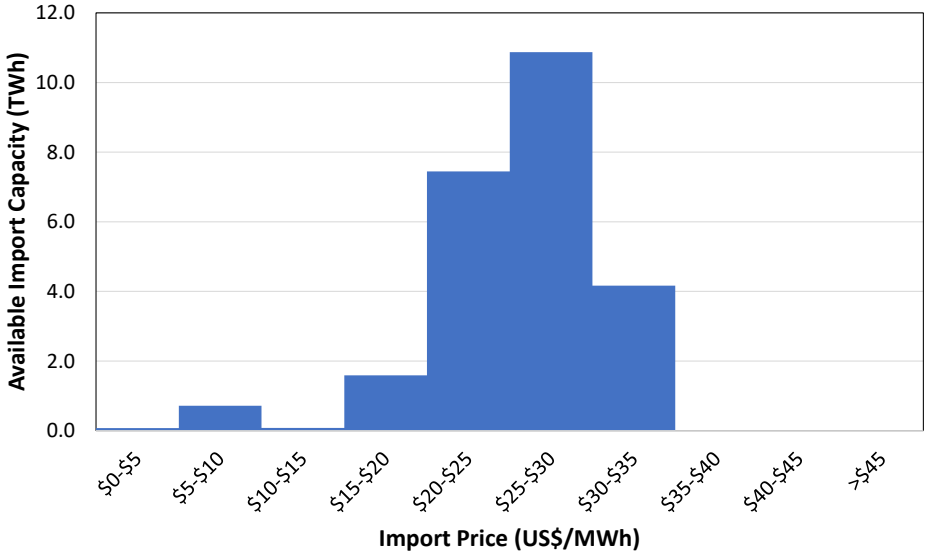
Low Demand

Excess Import Capacity Available for Arbitrage

2030

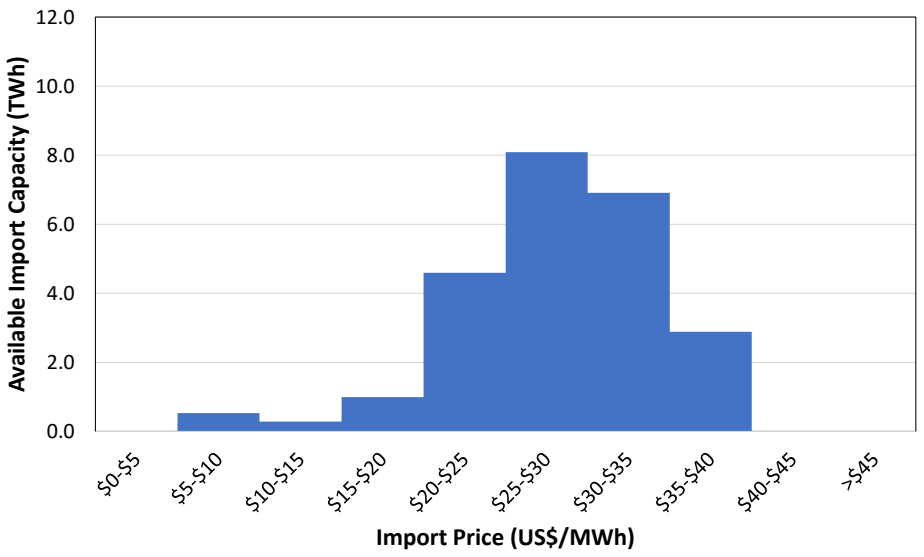
Before Carbon Cost and Transmission Losses

No CHPE, No NECEC



After Carbon Cost and Transmission Losses

No CHPE, No NECEC



In many cases it is less expensive to upgrade existing hydro before imports

Supply

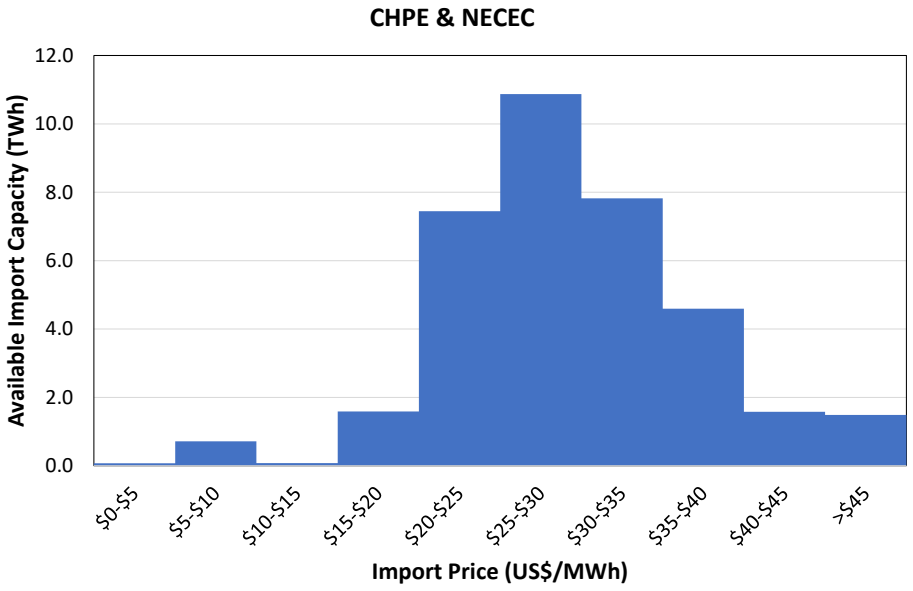
High demand and export lines increase arbitrage opportunities

High Demand

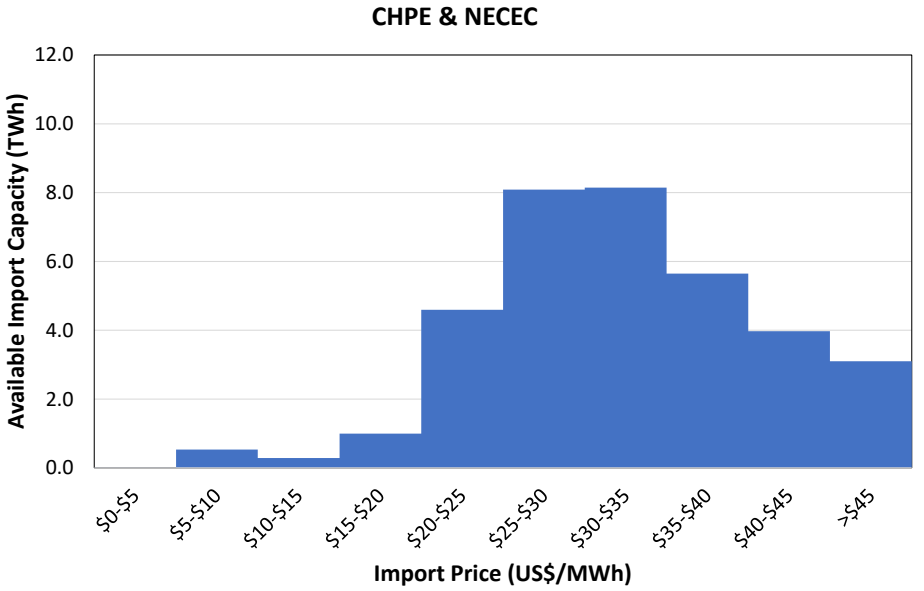
Excess Import Capacity Available for Arbitrage

2030

Before Carbon Cost and Transmission Losses



After Carbon Cost and Transmission Losses



However, carbon costs and losses can make supply build-out more economic

Hydro-Québec's Projected Demand and Supply

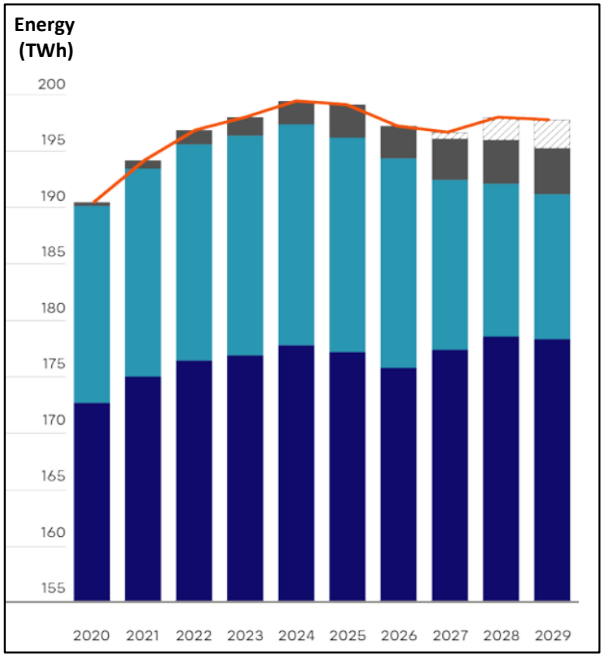
SUPPLY/DEMAND GAP

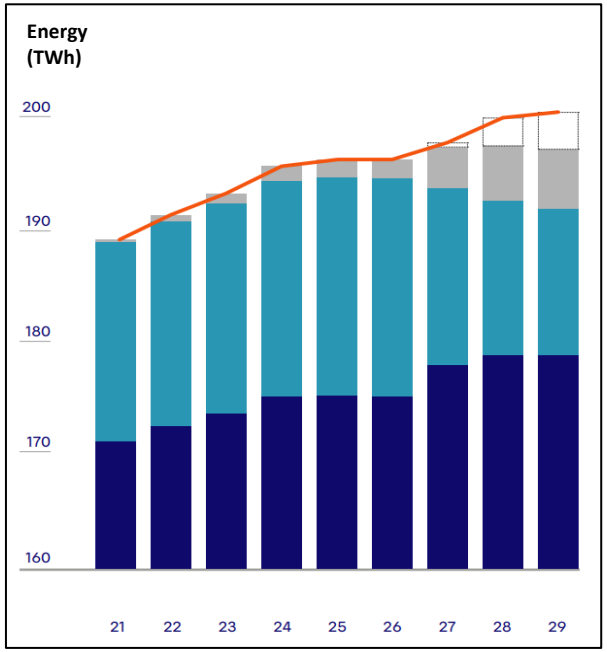
Supply/Demand Gap

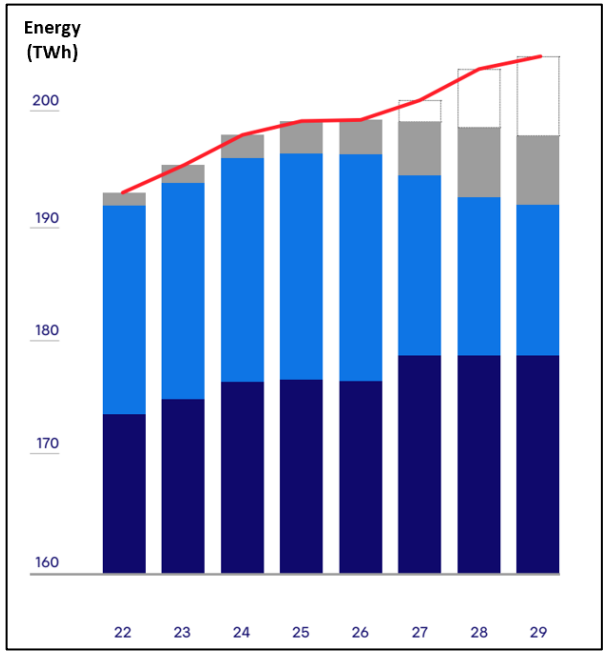
HQD projects a shortfall in energy supply by 2027

Evolution of Hydro-Québec Distributions Energy Supply Projections to 2029

Original (2019) → **2020 Update** → **2021 Update**





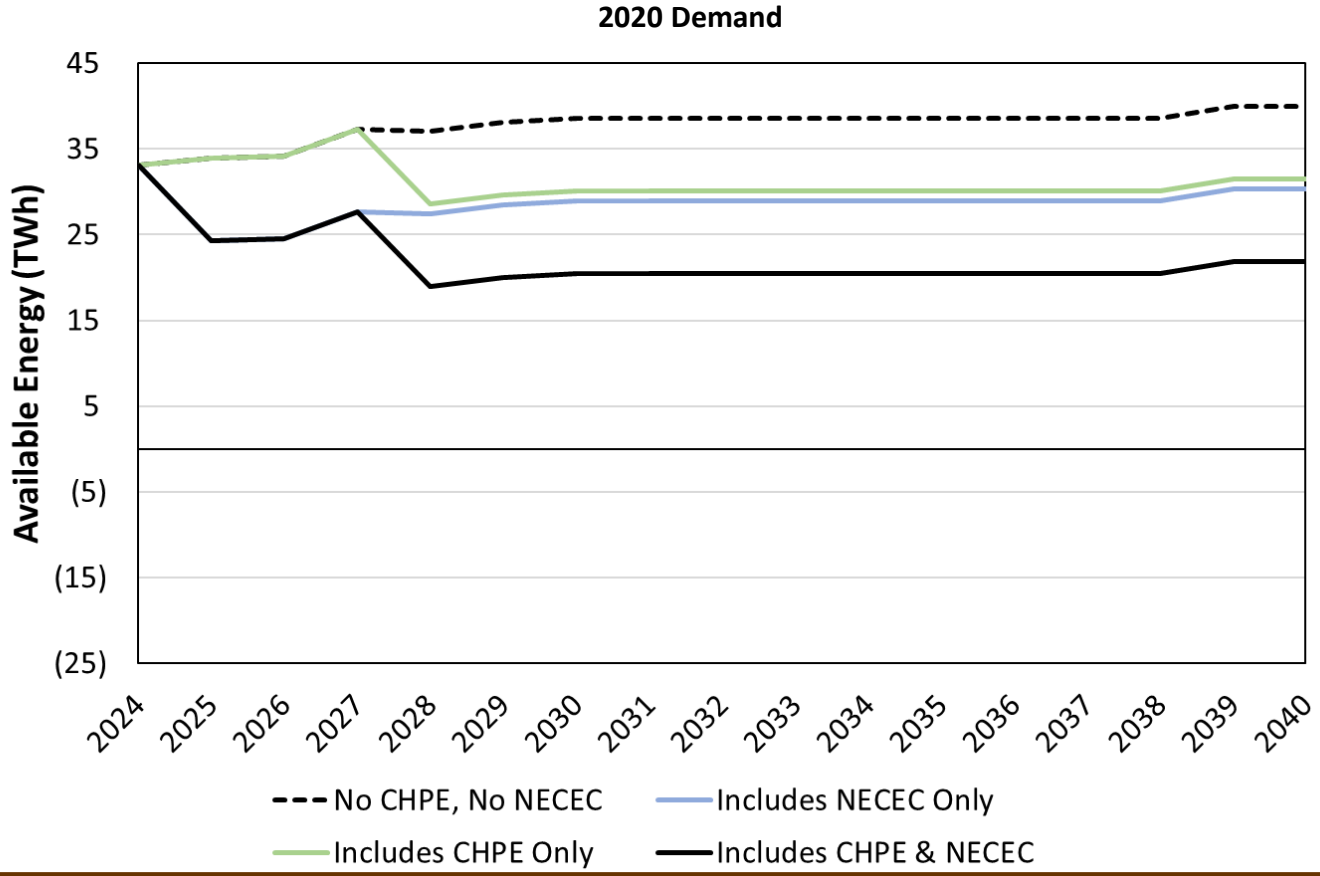


Source: Compiled using Hydro-Québec's 2021 Update to the 2020-2029 Energy Supply Plan.
http://www.regie-energie.qc.ca/audiences/Suivis/Suivi%20HQD_PlanAppro2020-2029/%C3%89tat%20d'avancement%202021.pdf

These projections do not include HQ Power's excess energy sold elsewhere

New transmission lines decreases energy available for Québec load

Excess Generation Available for Merchant Export Sales with 2020 Demand Held Constant Before Build-out

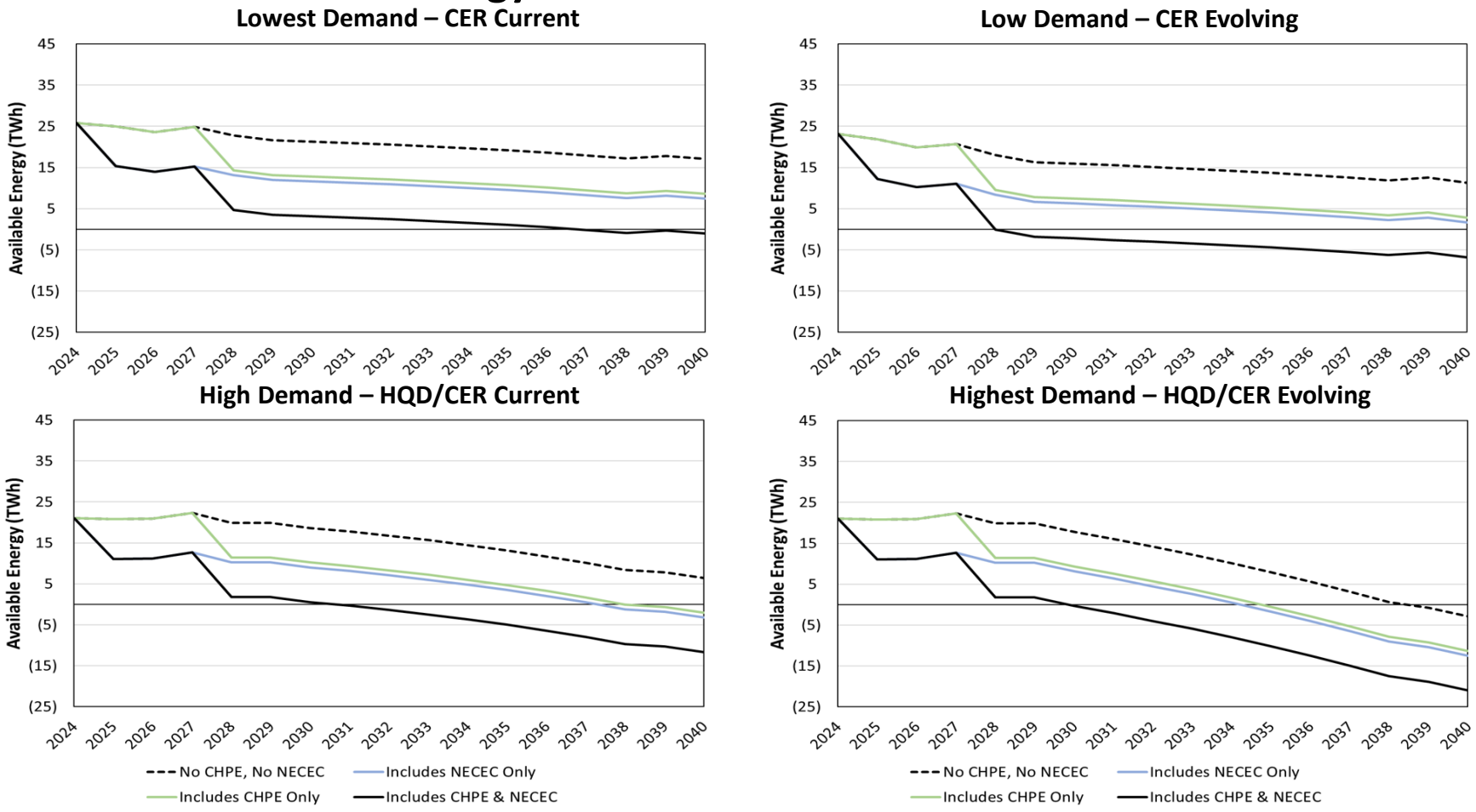


Excess energy available for export declines by the contracted amounts

Supply/Demand Gap

Higher demand forecasts decrease excess energy available for export

Excess Energy for Merchant Sales Before Build-out



Negative values indicate that Hydro-Quebec could fall short of its obligations

Many dynamic assumptions interact and impact the results

Interactions between Assumptions and Model

Assumption	Assumption Direction	Excess Energy	Import Opportunity
Quebec Load			
Export Contracts (CHPE and NECEC)			
Imports			
New Capacity Build-out			

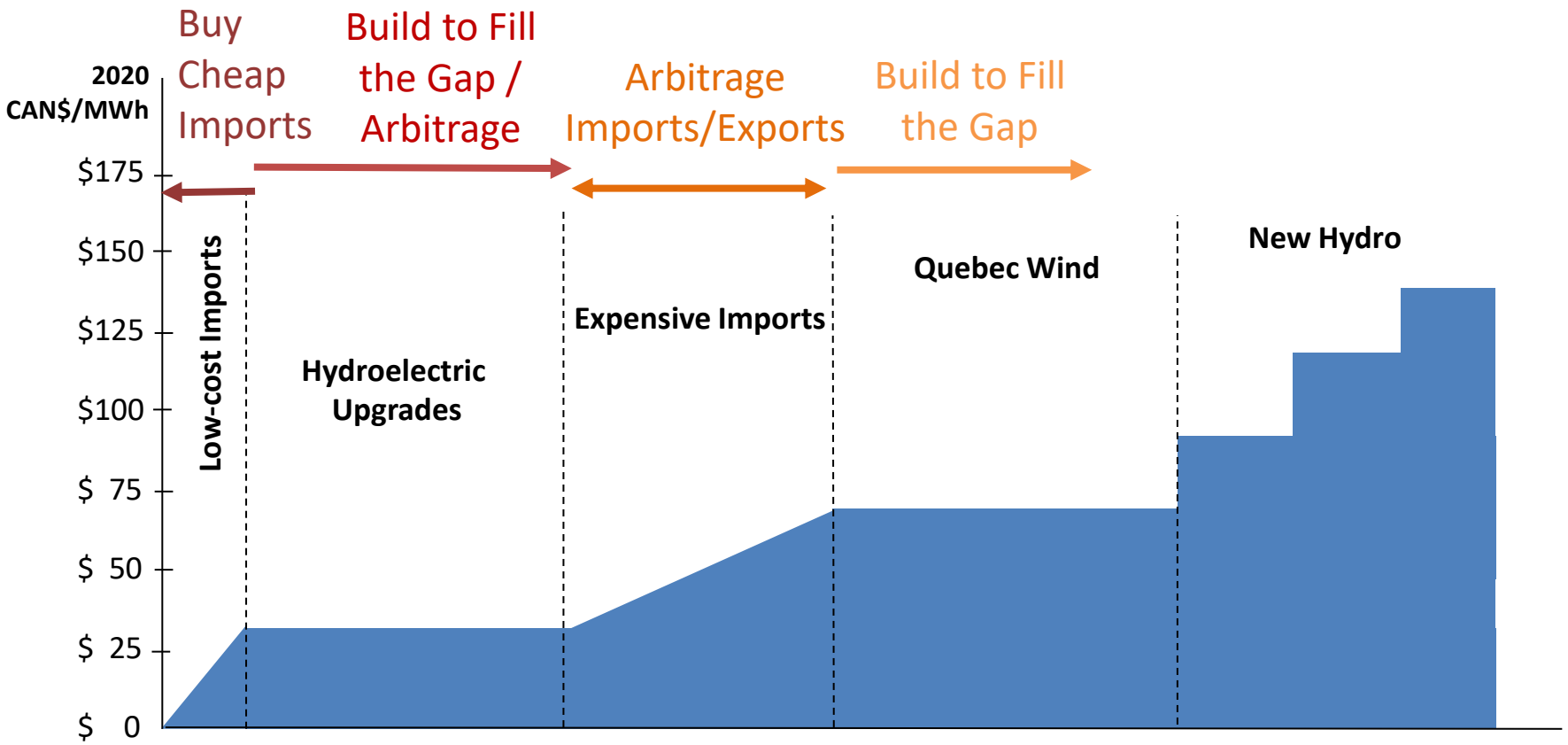
Prices in external markets are kept fixed in all scenarios

Hydro-Québec's Projected Demand and Supply

ECONOMIC BUILD-OUT

The economic build-out rule does more than just fill the gap

Illustration of Supply Build-out



New builds and purchases occur if they can arbitrage economic opportunities

ENERGYZT

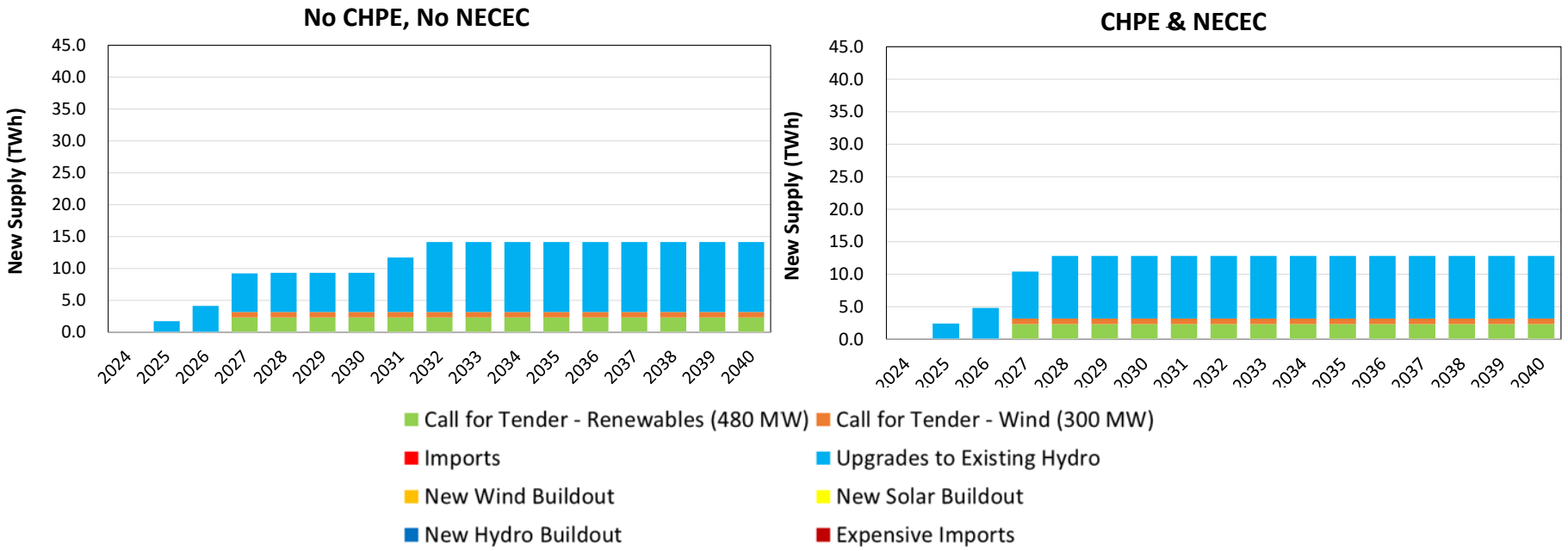
Economic Build-out

With constant demand, excess energy is sold and build-out deferred

2020 Demand Held Constant

Incremental Build-out to Arbitrage

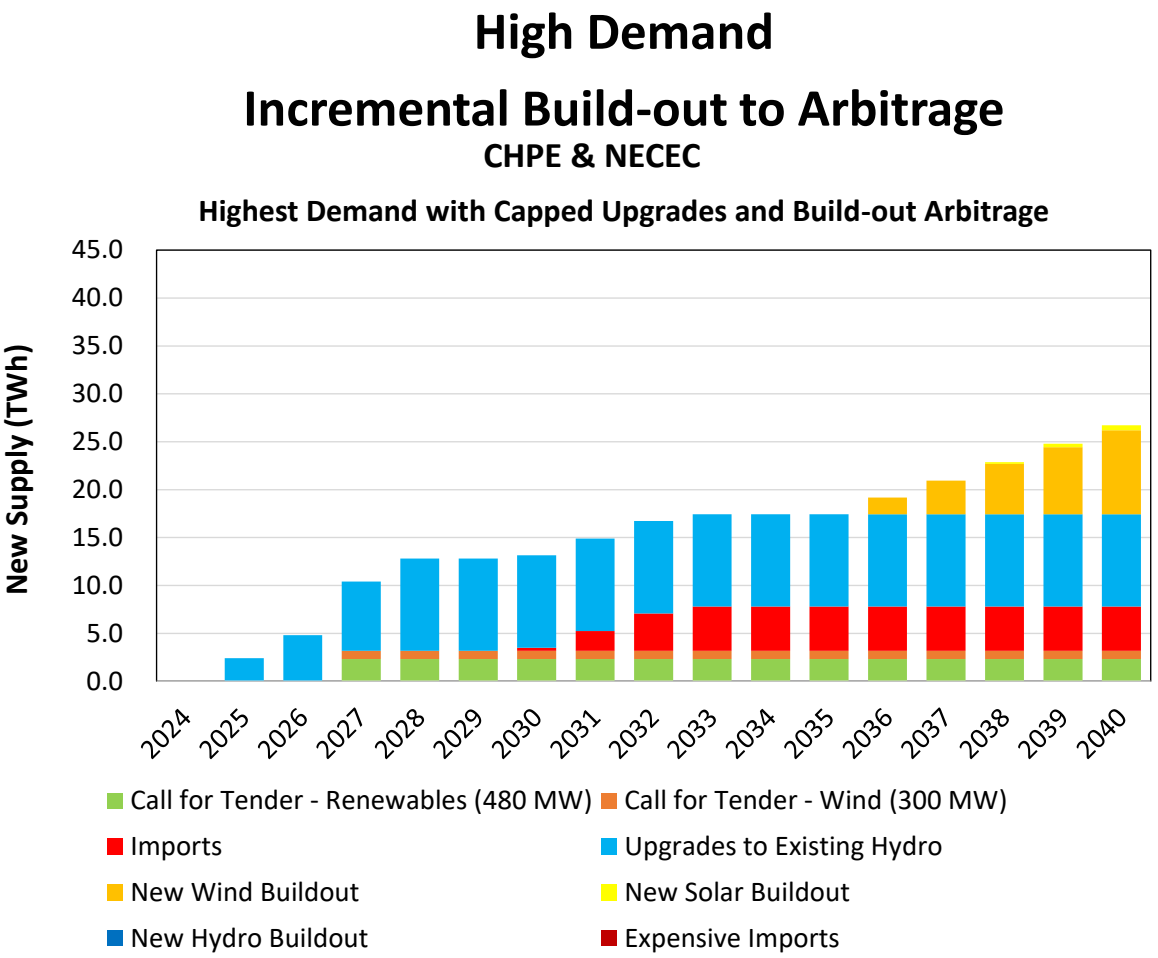
Constant Demand with Capped Hydro Upgrades and Build-out Arbitrage



CHPE/NECEC requires earlier build-out to meet better arbitrage opportunities

Economic Build-out

With high demand, new export lines increase build-out requirements



With higher demand and exports, Hydro-Quebec needs to build and buy more

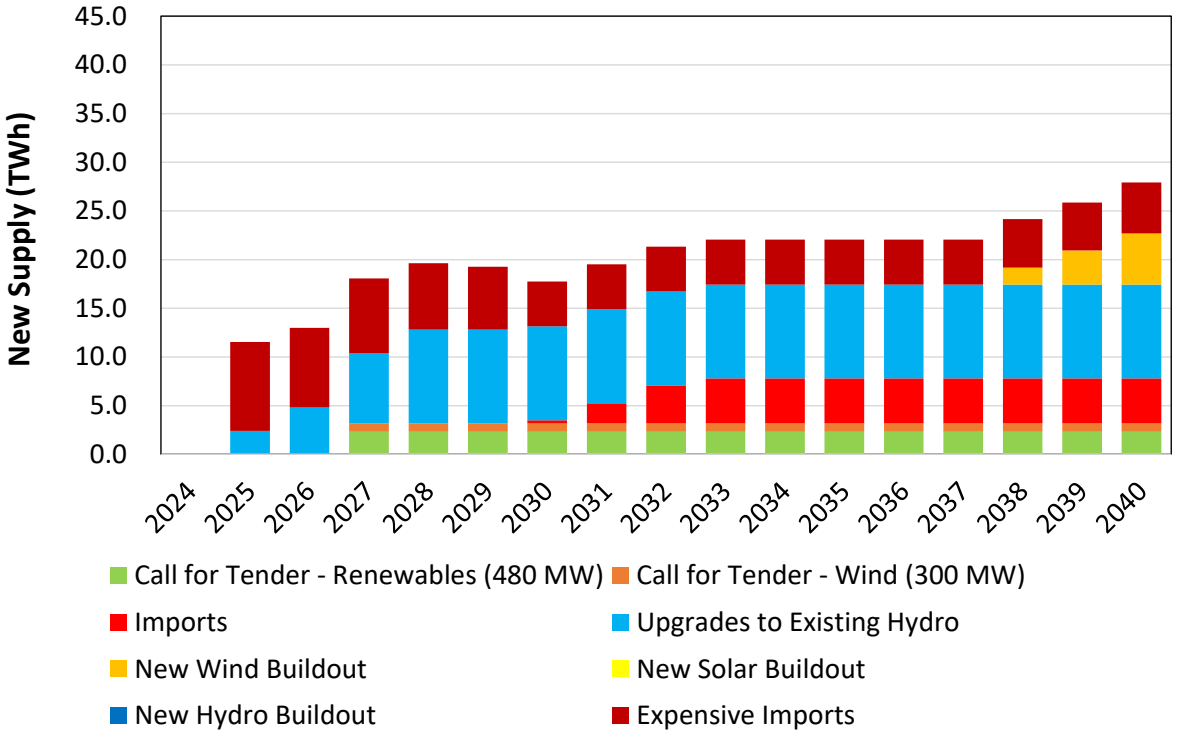
New transmission lines also increase arbitrage opportunities

High Demand

Incremental Build-out and Imports to Arbitrage

CHPE & NECEC

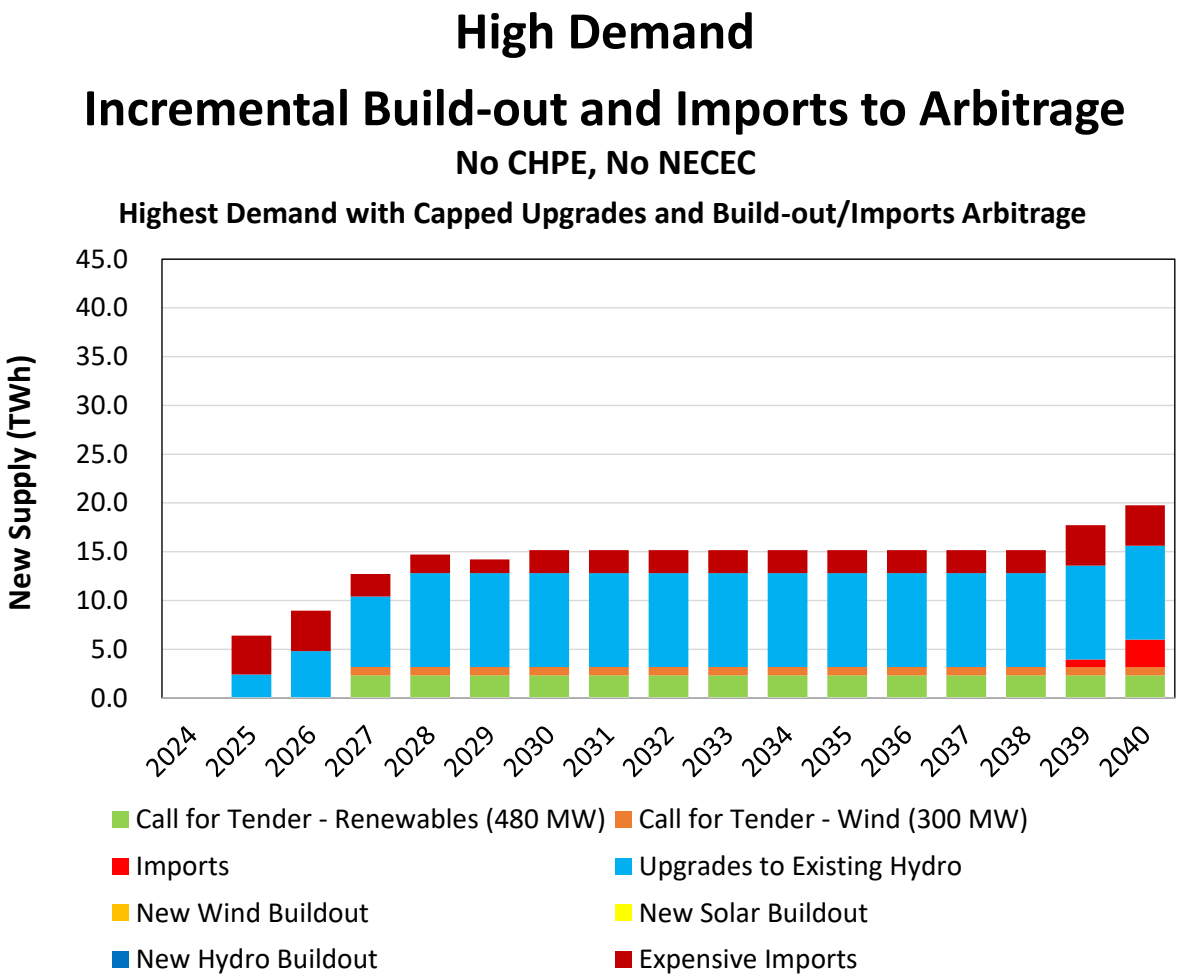
Highest Demand with Capped Upgrades and Build-out/Imports Arbitrage



Expensive imports can service demand from new transmission lines and load

Economic Build-out

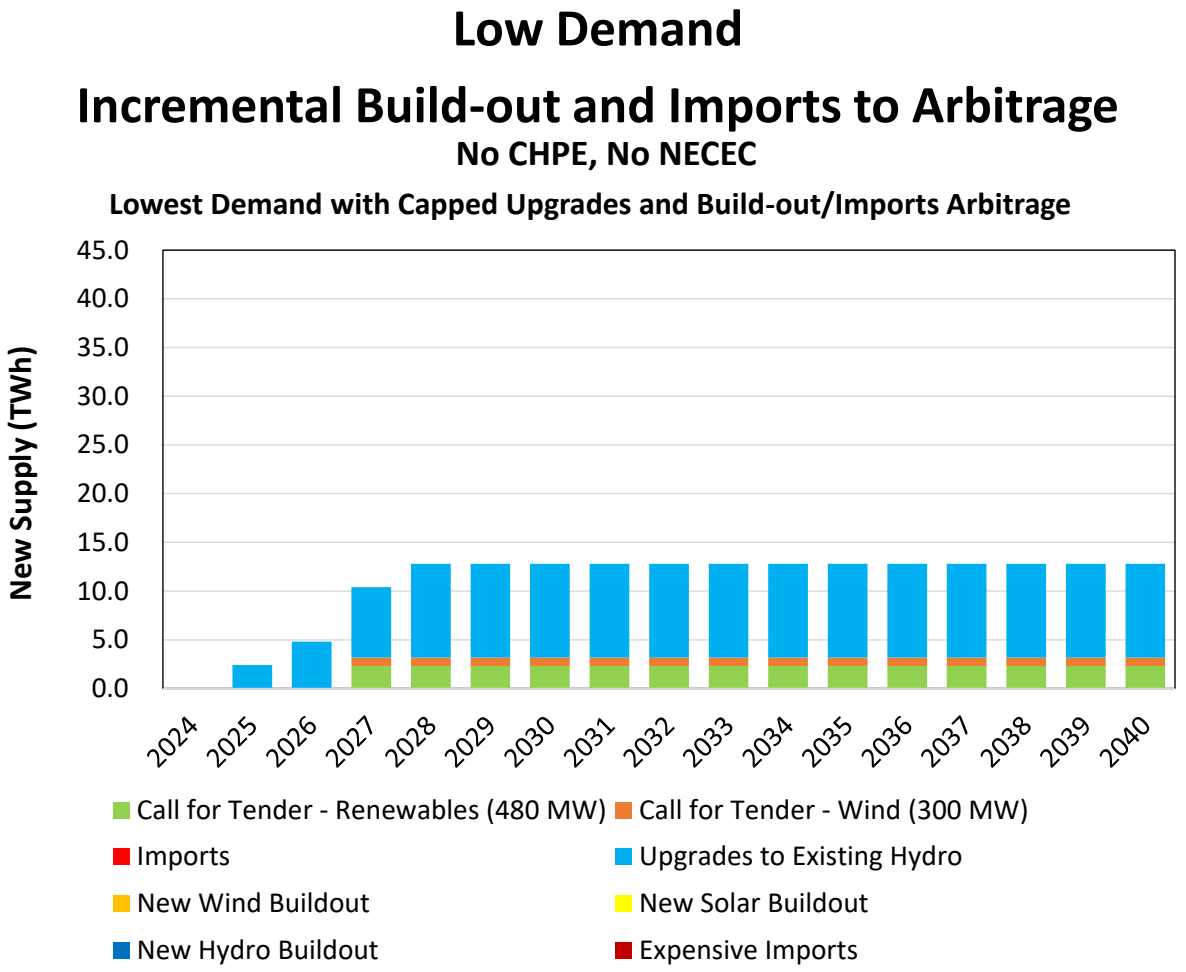
Without new export lines, total obligations and build-out are lower



Without CHPE/NECEC, existing lines are filled more often allowing for less arbitrage

Economic Build-out

Lower load growth decreases the need for build-outs and imports



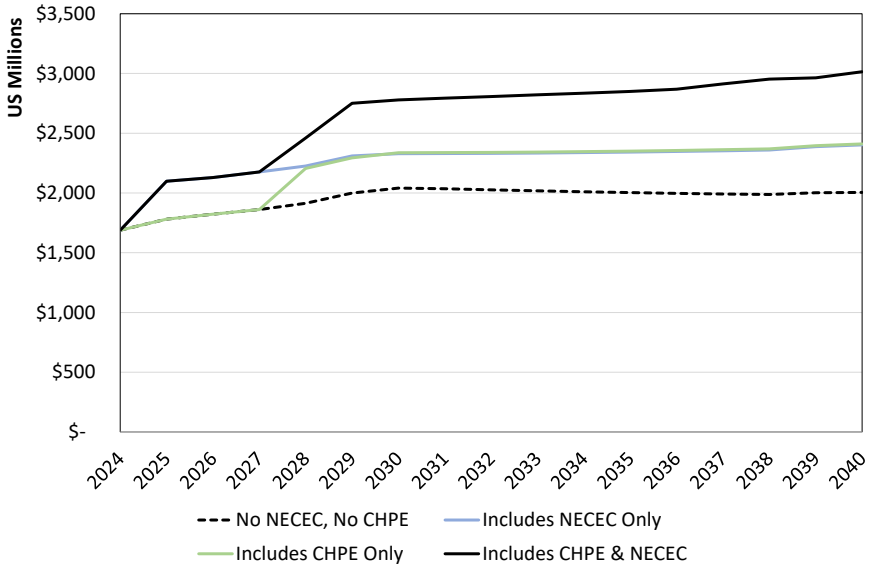
Lower load growth increases excess energy, but still allows for arbitrage build-out

Economic Build-out

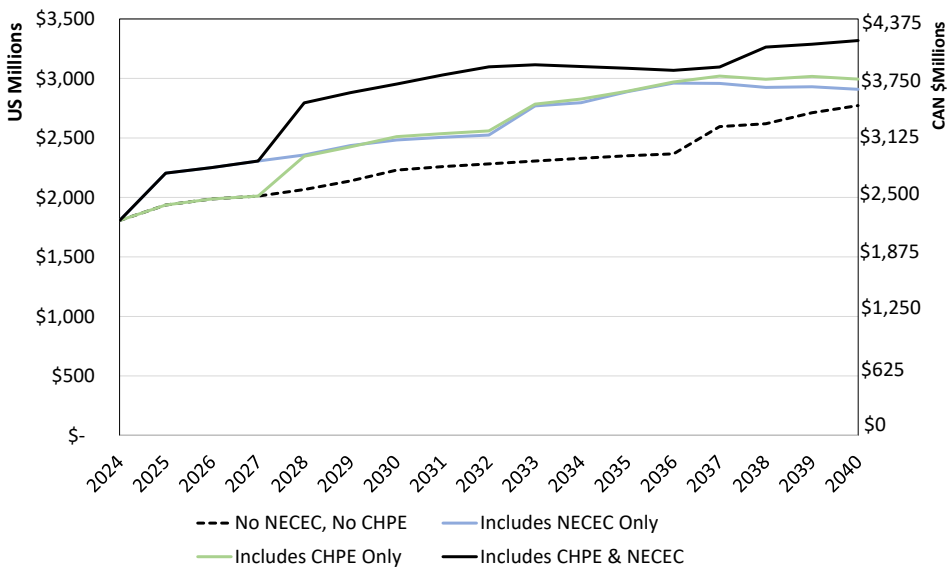
Net revenues vary by scenario and depend on demand and supply

Incremental Net Revenues due to New Build-out/Purchases

Net Revenues – Lowest Load Growth (CER Current)



Net Revenues – Highest Load Growth (HQ/CER Evolving)



Firm energy exports to the US generate higher margins than regulated sales

Hydro-Québec's Projected Demand and Supply

CONCLUSIONS

Conclusions

By 2025, planned hydro upgrades and imports are sufficient to cover demand

2025

Incremental Build-out/Purchases (TWh)

Lowest Demand Export Scenario	Call for Tender - Renewables (480 MW)	Call for Tender - Wind (300 MW)	Upgrades to Existing Hydro	New Wind Buildout	New Hydro Buildout	Low-cost Imports	Expensive Imports
No CHPE/NECEC	0.00	0.00	2.41	0.00	0.00	0.00	0.00
CHPE Only	0.00	0.00	2.41	0.00	0.00	0.00	0.00
NECEC Only	0.00	0.00	2.41	0.00	0.00	0.00	9.13
Both CHPE/NECEC	0.00	0.00	2.41	0.00	0.00	0.00	9.13

Highest Demand Export Scenario	Call for Tender - Renewables (480 MW)	Call for Tender - Wind (300 MW)	Upgrades to Existing Hydro	New Wind Buildout	New Hydro Buildout	Low-cost Imports	Expensive Imports
No CHPE/NECEC	0.00	0.00	2.41	0.00	0.00	0.00	3.98
CHPE Only	0.00	0.00	2.41	0.00	0.00	0.00	3.98
NECEC Only	0.00	0.00	2.41	0.00	0.00	0.00	9.13
Both CHPE/NECEC	0.00	0.00	2.41	0.00	0.00	0.00	9.13

The next set of procurements in 2027 relieves the need for expensive imports

Conclusions

By 2030, Québec's future buildout and purchases depend on various factors

2030

Incremental Build-out/Purchases (TWh)

Lowest Demand Export Scenario	Call for Tender - Renewables (480 MW)	Call for Tender - Wind (300 MW)	Upgrades to Existing Hydro	New Wind Buildout	New Hydro Buildout	Low-cost Imports	Expensive Imports
No CHPE/NECEC	2.31	0.87	9.64	0.00	0.00	0.00	0.00
CHPE Only	2.31	0.87	9.64	0.00	0.00	0.00	0.00
NECEC Only	2.31	0.87	9.64	0.00	0.00	0.00	4.62
Both CHPE/NECEC	2.31	0.87	9.64	0.00	0.00	0.00	4.62

Highest Demand Export Scenario	Call for Tender - Renewables (480 MW)	Call for Tender - Wind (300 MW)	Upgrades to Existing Hydro	New Wind Buildout	New Hydro Buildout	Low-cost Imports	Expensive Imports
No CHPE/NECEC	2.31	0.87	9.64	0.00	0.00	0.00	2.35
CHPE Only	2.31	0.87	9.64	0.00	0.00	0.00	2.35
NECEC Only	2.31	0.87	9.64	0.00	0.00	0.00	4.62
Both CHPE/NECEC	2.31	0.87	9.64	0.00	0.00	0.32	4.62

By 2030, most needs can be met with the tenders, hydro upgrades and imports

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Conclusions

By 2035, Québec's mix includes more imports to cover demand growth

2035

Incremental Build-out/Purchases (TWh)

Lowest Demand Export Scenario	Call for Tender - Renewables (480 MW)	Call for Tender - Wind (300 MW)	Upgrades to Existing Hydro	New Wind Buildout	New Hydro Buildout	Low-cost Imports	Expensive Imports
No CHPE/NECEC	2.31	0.87	9.64	0.00	0.00	0.00	0.00
CHPE Only	2.31	0.87	9.64	0.00	0.00	0.00	0.00
NECEC Only	2.31	0.87	9.64	0.00	0.00	0.00	4.62
Both CHPE/NECEC	2.31	0.87	9.64	0.00	0.00	0.00	4.62

Highest Demand Export Scenario	Call for Tender - Renewables (480 MW)	Call for Tender - Wind (300 MW)	Upgrades to Existing Hydro	New Wind Buildout	New Hydro Buildout	Low-cost Imports	Expensive Imports
No CHPE/NECEC	2.31	0.87	9.64	0.00	0.00	0.00	2.35
CHPE Only	2.31	0.87	9.64	0.00	0.00	0.54	2.35
NECEC Only	2.31	0.87	9.64	0.00	0.00	1.69	4.62
Both CHPE/NECEC	2.31	0.87	9.64	0.00	0.00	4.62	4.62

Most of the time imports are not needed because of economic build-out

Conclusions

Higher export opportunities increase gross and net revenues

Total Gross Revenues (2020$CAN billions) – Lowest Load Growth

Export Scenario	2025	2030	2035
No CHPE/NECEC	$11.72	$12.38	$12.33
CHPE Only	$11.72	$12.75	$12.77
NECEC Only	$12.32	$12.86	$12.87
Both CHPE/NECEC	$12.32	$13.42	$13.51

Total Net Revenues (2020$CAN billions) – Lowest Load Growth

Export Scenario	2025	2030	2035
No CHPE/NECEC	$2.23	$2.55	$2.50
CHPE Only	$2.23	$2.92	$2.94
NECEC Only	$2.63	$2.92	$2.93
Both CHPE/NECEC	$2.63	$3.48	$3.57

With low load growth, new export lines increase revenues and margins

Conclusions

Higher load growth can be accommodated with existing rates

Total Revenues (2020$CAN Billions) – Highest Load Growth

Export Scenario	2025	2030	2035
No CHPE/NECEC	$12.00	$12.67	$12.82
CHPE Only	$12.00	$13.02	$13.51
NECEC Only	$12.44	$13.04	$13.58
Both CHPE/NECEC	$12.44	$13.63	$13.91

Total Net Revenues (2020$CAN Billions) – Highest Load Growth

Export Scenario	2025	2030	2035
No CHPE/NECEC	$2.42	$2.79	$2.94
CHPE Only	$2.42	$3.14	$3.62
NECEC Only	$2.76	$3.10	$3.61
Both CHPE/NECEC	$2.76	$3.69	$3.86

Hydro-Québec's incremental gross/net revenues would increase with higher load

Hydro-Québec's Projected Generation Mix

APPENDIX A: ASSUMPTIONS

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Appendix A: Assumptions

U.S. to Canadian exchange rates have varied between $1.25 to $1.38

U.S. Yearly Average Exchange Rates
2016 - 2021

Yearly Average Exchange Rates for Converting Foreign Currencies into U.S. Dollars

Country	Currency	2021	2020	2019	2018	2017	2016
Afghanistan	Afghani	83.484	76.651	77.579	73.598	71.086	70.645
Algeria	Dinar	135.011	126.741	119.402	117.409	115.876	114.431
Argentina	Peso	95.098	70.635	48.192	28.167	17.227	15.359
Australia	Dollar	1.332	1.452	1.439	1.340	1.358	1.400
Bahrain	Dinar	0.377	0.377	0.377	0.395	0.395	0.395
Brazil	Real	5.395	5.151	3.946	3.655	3.322	3.632
Canada	Dollar	1.254	1.341	1.327	1.297	1.350	1.379

Source: IRS, https://www.irs.gov/individuals/international-taxpayers/yearly-average-currency-exchange-rates

To convert results, the model applies a 2021 exchange rate of CAN$1.25 to US$1

Appendix A: Assumptions

Hydro-Québec has access to alternative ways to meet load and arbitrage

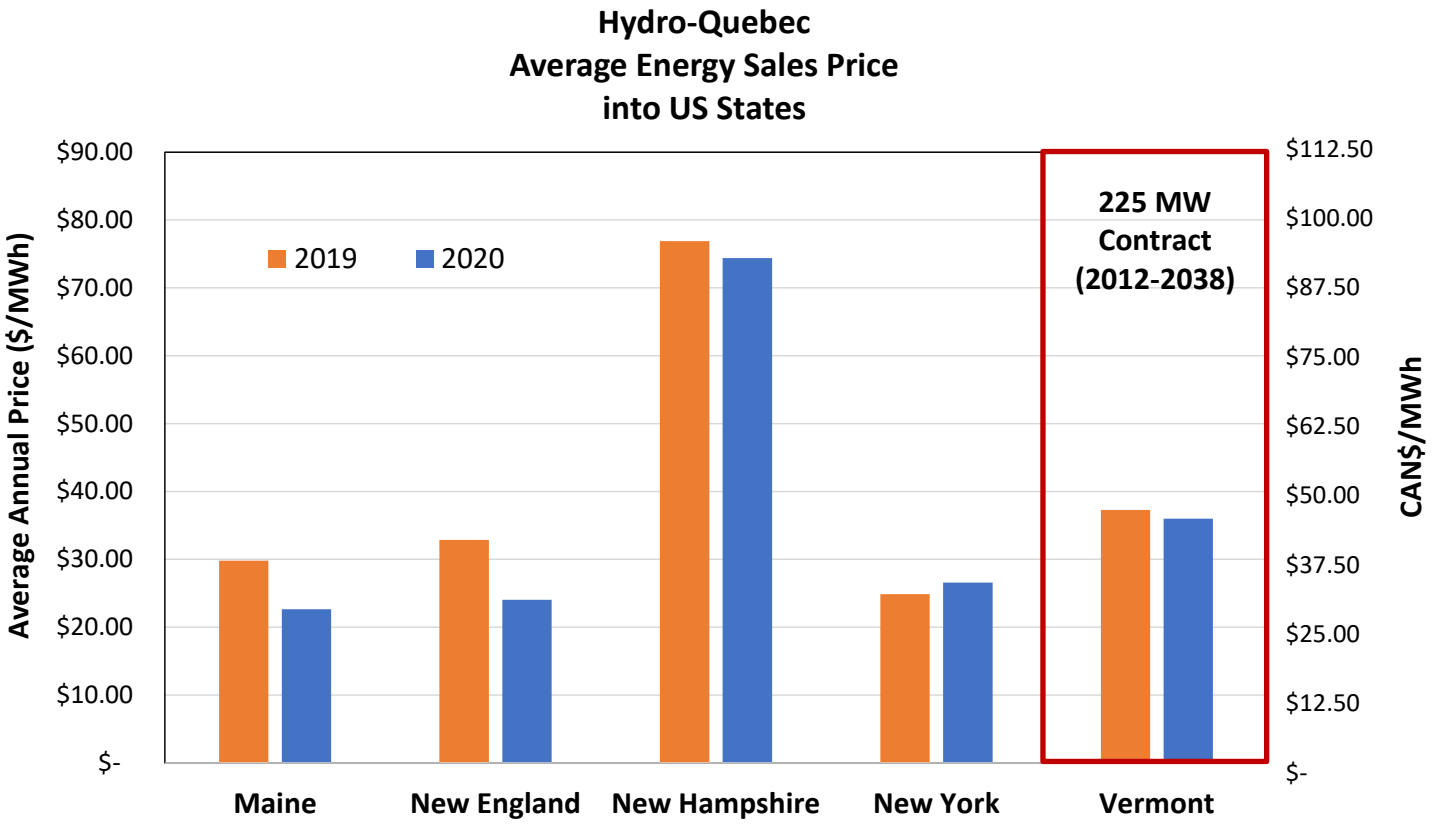
Assumed Costs for HQ to Procure Additional Energy (2020$CAN/MWh)

Component	Purchase External Spot Energy	Upgrade Existing HQ Hydro	Purchase Spot Energy from the U.S.	Buy Wind from IPPs	Forego Firm PPA Exports (Scenarios)	HQ Build New Hydro
Energy Cost (2020$CAN/MWh)	$0 - $29	$26	$29 - $66	$63	$65	$95 - $132
Capacity/ Energy Limits	Up to ~3.5 TWh	500 MW / year 2,000 MW Total ~9.5 TWh	Depends on Merchant Exports	500 MW / year 3,000 MW Total ~10.5 TWh	NECEC: 9.54 TWh CHPE: 10.5 TWh	500 MW/year 2,000 MW Total ~10 TWh
Carbon Credits	Included as cost in analysis	Included	Included as cost in analysis	Included	Included	Included
Losses	2%	5.5%	2%	5.5%	7.5%	5.5%
Transmission	$0	$3	$0	$3	$0	$3
Total Cost (2020$CAN/MWh)	**$0 - $29**	**$29**	**$29 - $66**	**$66**	**$65**	**$98 - $135**

The cost of potential alternatives range from imports to building new hydro dams

Appendix A: Assumptions

Spot market prices have averaged CAN$25 - $50 / MWh the past two years



Source: Vermont, Québec sign Hydro Deal,
https://www.cbc.ca/news/canada/montreal/Québec-vermont-sign-hydro-deal-

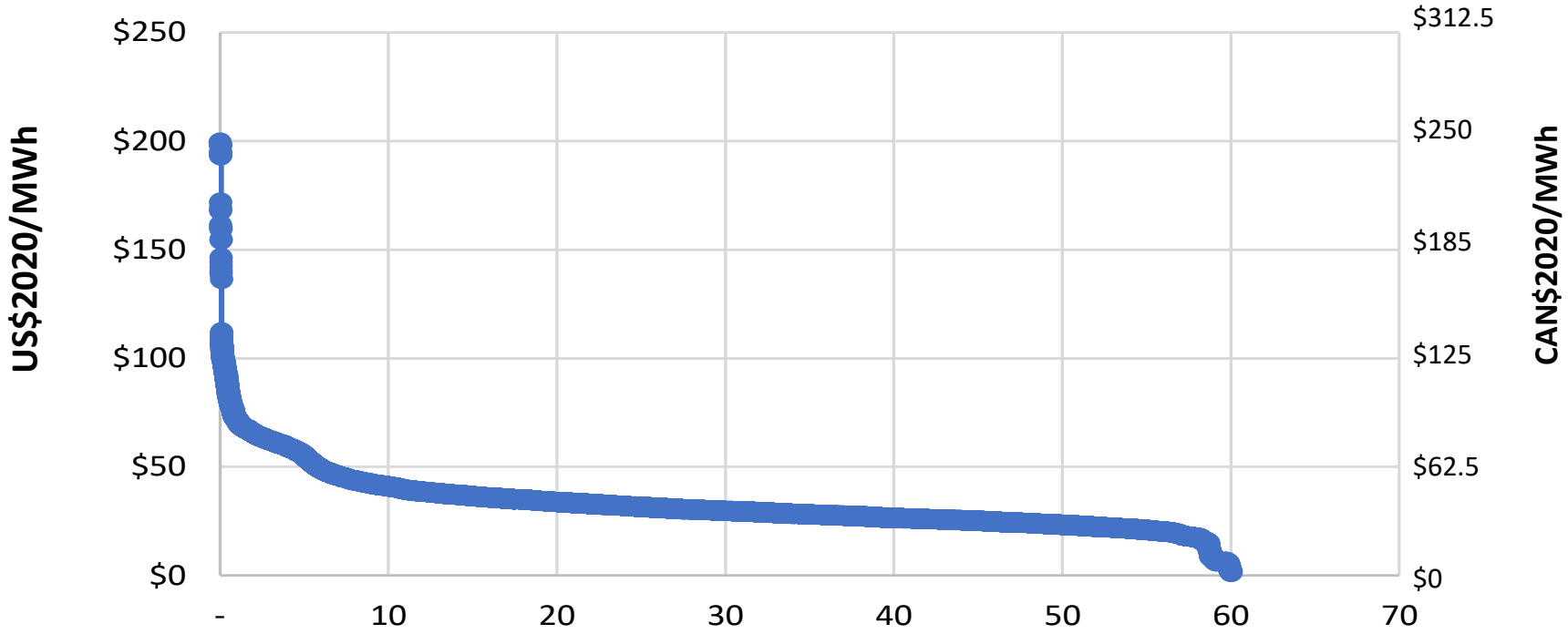
The lowest-priced hours during off-peak periods would be US$5 to $26 / MWh

Export prices are used to allocate excess energy to external markets

Illustration of Spot Market Prices Across All Transmission Lines

Before Carbon Prices and Losses

Example: 2030

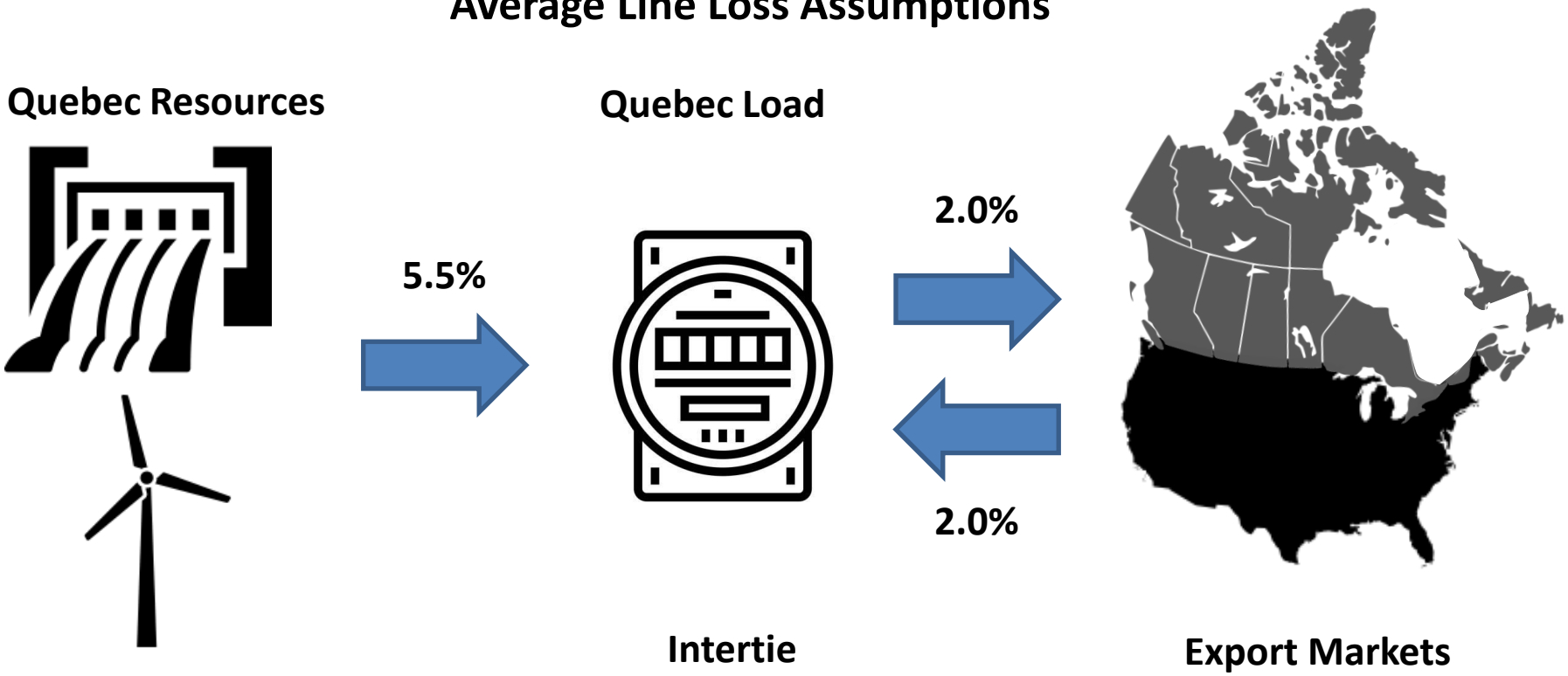


Source: Energyzt model runs

The model holds export prices constant across all scenarios and fixed after 2030

Losses occur internally and through the interties

Average Line Loss Assumptions

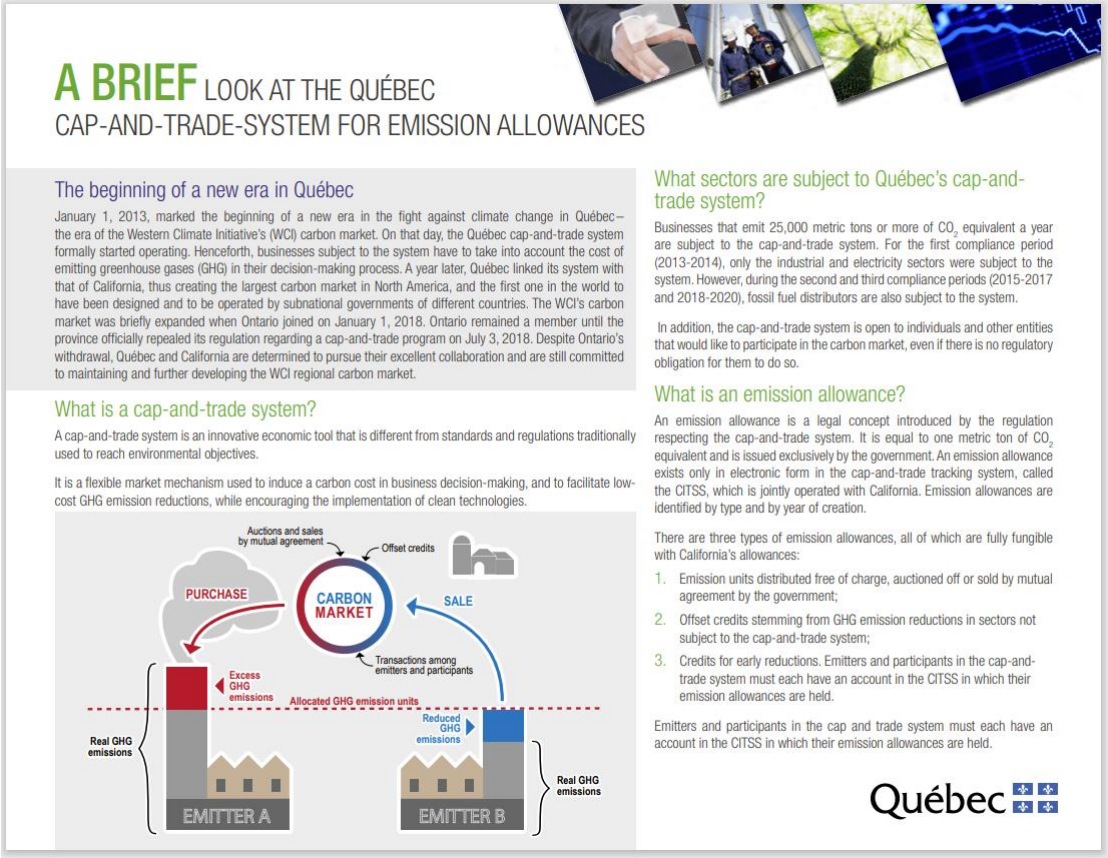


Internal line losses applied to generators; external increases build-out for exports

Appendix A: Assumptions

Quebec's GHG cap and trade system is assumed to apply to imports

Quebec Imports Could be Subject to Carbon Prices



A BRIEF LOOK AT THE QUÉBEC
CAP-AND-TRADE-SYSTEM FOR EMISSION ALLOWANCES

The beginning of a new era in Québec

January 1, 2013, marked the beginning of a new era in the fight against climate change in Québec – the era of the Western Climate Initiative's (WCI) carbon market. On that day, the Québec cap-and-trade system formally started operating. Henceforth, businesses subject to the system have to take into account the cost of emitting greenhouse gases (GHG) in their decision-making process. A year later, Québec linked its system with that of California, thus creating the largest carbon market in North America, and the first one in the world to have been designed and to be operated by subnational governments of different countries. The WCI's carbon market was briefly expanded when Ontario joined on January 1, 2018. Ontario remained a member until the province officially repealed its regulation regarding a cap-and-trade program on July 3, 2018. Despite Ontario's withdrawal, Québec and California are determined to pursue their excellent collaboration and are still committed to maintaining and further developing the WCI regional carbon market.

What is a cap-and-trade system?

A cap-and-trade system is an innovative economic tool that is different from standards and regulations traditionally used to reach environmental objectives.

It is a flexible market mechanism used to induce a carbon cost in business decision-making, and to facilitate low-cost GHG emission reductions, while encouraging the implementation of clean technologies.

What sectors are subject to Québec's cap-and-trade system?

Businesses that emit 25,000 metric tons or more of CO_2 equivalent a year are subject to the cap-and-trade system. For the first compliance period (2013-2014), only the industrial and electricity sectors were subject to the system. However, during the second and third compliance periods (2015-2017 and 2018-2020), fossil fuel distributors are also subject to the system.

In addition, the cap-and-trade system is open to individuals and other entities that would like to participate in the carbon market, even if there is no regulatory obligation for them to do so.

What is an emission allowance?

An emission allowance is a legal concept introduced by the regulation respecting the cap-and-trade system. It is equal to one metric ton of CO_2 equivalent and is issued exclusively by the government. An emission allowance exists only in electronic form in the cap-and-trade tracking system, called the CITSS, which is jointly operated with California. Emission allowances are identified by type and by year of creation.

There are three types of emission allowances, all of which are fully fungible with California's allowances:

1. Emission units distributed free of charge, auctioned off or sold by mutual agreement by the government;
2. Offset credits stemming from GHG emission reductions in sectors not subject to the cap-and-trade system;
3. Credits for early reductions. Emitters and participants in the cap-and-trade system must each have an account in the CITSS in which their emission allowances are held.

Emitters and participants in the cap and trade system must each have an account in the CITSS in which their emission allowances are held.

Québec

Source: Quebec, https://www.environnement.gouv.qc.ca/changements/carbone/documents-spede/in-brief.pdf

A constant price for carbon per market is added to import prices

Appendix A: Assumptions

Quebec's GHG emissions are auctioned off via quarterly auctions

Auction Results for Greenhouse Gas Emissions and Payments to the Electrification and Climate Change Fund (CAN$)

Québec-California joint auctions	Current Years		Future Years		Proceeds paid to the ECCF [3]
	Units sold	Price	Units sold	Price	
November 25, 2014	1,049,114	$13.68	1,527,000	$13.41	$34,687,822.04
February 18, 2015 [4]	11,171,647	$15.14	1,474,000	$15.01	$191,239,426.43
May 21, 2015	13,118,323	$15.01	1,386,463	$14.78	$217,312,458.20
August 18, 2015	11,171,647	$16.39	1,474,000	$16.10	$207,019,309.08
November 17, 2015	11,171,647	$17,00	1,474,000	$16.89	$214,622,654.04
February 17, 2016	11,149,718	$17,64	1,320,037	$17.64	$219,533,976.21
May 18, 2016	1,085,305	$16.40	128,887	$16.40	$19,999,969.52
August 16, 2016	3,520,244	$16.45	108,440	$16.45	$59,541,579.86
November 15, 2016	8,942,291	$17.29	143,835	$17.29	$156,984,054.36
February 22, 2017	1,555,604	$17.84	98,660	$17.84	$29,481,711.11
May 16, 2017	8,676,131	$18.82	297,950	$18.51	$168,413,711.64
August 15, 2017	8,676,131	$18.74	1,368,500	$18.49	$187,694,463.82
November 14, 2017	10,845,165	$19.10	1,368,500	$18.72	$232,877,186.73
February 21, 2018[5]	9,663,522	$18.44	953,314	$18.34	$196,049,713.71
May 15, 2018[5]	9,663,522	$18.72	673,301	$18.56	$193,515,761.42
August 14, 2018	9,663,522	$19.77	1,381,500	$19.57	$217,946,931.01
November 14, 2018	9,663,522	$20.27	1,381,500	$20.30	$223,928,934.91
February 20, 2019	9,574,976	$20.82	894,008	$20.68	$217,730,082.38
May 14, 2019	9,574,976	$23.48	1,350,500	$23.42	$256,357,481.01
August 20, 2019	9,574,976	$22.82	1,350,500	$22,41	$248,705,259.52
November 19, 2019	9,574,980	$22.46	1,350,500	$22.20	$245,213,275.76
February 19, 2020	9,068,906	$23.69	1,319,750	$23.86	$246,468,654.35
May 20, 2020	3,335,153	$23.17	268,295	$23.17	$81,893,811.48
August 18, 2020	6,444,090	$22.03	1,319,750	$22.10	$171,045,619.91
November 17, 2020	7,255,128	$22.15	1,319,750	$22.70	$190,486,111.81
February 17, 2021	7,230,807	$22.58	1,288,750	$22.84	$192,697,336.10
May 19, 2021	9,861,797	$22.66	1,288,750	$22.95	$253,011,970.65
August 18, 2021	9,038,508	$29.41	1,288,750	$29.90	$304,236,334.56
November 17, 2021	9,038,508	$35.47	1,288,750	$42.68	$375,948,005.00
February 16, 2022	9,093,457	$37.14	1,120,973	$25.10	$365,891,930.48
Sub-total	**249,453,317**		**32,008,913**		**5,920,535,537.10**
Total	**253,256,428**		**37,758,913**		**6,027,596,351.39**

Source: Quebec Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC), https://www.environnement.gouv.qc.ca/changements/carbone/revenus-en.htm

Quebec's average carbon price is assumed to be the average of recent auctions (CAN$30.99)

Carbon prices are assumed to apply to non-firm imports into Québec

Assumed Carbon Price Adder

Quebec

$0/MWh

Varies by Import Market Based on Default Values

Import Markets

Import Source:	New Brunswick	Ontario	ISO-NE	NYISO
Carbon Price (CAN$/Tonne)	$30.99	$30.99	$30.99	$30.99
GHG Emissions Factor (Tonne/MWh)	0.282	0.03	0.259	0.211
Import Carbon Price (CAN$/MWh)	**$8.74**	**$0.93**	**$8.03**	**$6.54**
Import Carbon Price (US$/MWh)	**$6.99**	**$0.74**	**$6.42**	**$5.23**

The carbon price assumes different GHG emission factors for each import location

Appendix A: Assumptions

Emissions from imports account for differences in fuel mixes

Default Greenhouse Gas Emissions Factors for Canadian Provinces and U.S. Northeast

	Canadian provinces and North American markets	Default emission factor (metric ton GHG/MWh)
CAN Imports	Newfoundland and Labrador	0.026
	Nova Scotia	0.724
	New Brunswick	0.282
	Québec	0.001
	Ontario	0.030
	Manitoba	0.001
U.S. Imports	Vermont	0.005
	New England Independent System Operator (NE-ISO), including all or part of the following states: - Connecticut - Massachusetts - Maine - Rhode Island - Vermont - New Hampshire	0.259
	New York Independent System Operator (NY-ISO)	0.211

Source: LegisQuebec, https://www.legisquebec.gouv.qc.ca/en/document/cr/Q-2,%20r.%2015

Emission levels vary depending on the market imports are being sourced from

ENERGYZT

Appendix A: Assumptions

A 2018 study provides estimates of hydroelectric upgrade and build-out costs

Estimated Cost of Incremental Hydroelectric Power Production (US $2018)

Hydro Bin	Potential (TWh)*	Levelized Fixed Cost ($/kW-year)	Levelized Cost of Electricity ($/MWh)
1	157	Current: 106 Post-2030: 133	Current: 20 Post 2030: 25
2	10	372	70
3	10	531	100
4	15+	690	130

- Current dispatchable hydro is 144 TWh, of which 4 TWh tends to be spilled each year, resulting in a maximum output of 140 TWh. The remainder of hydro bin one requires no new impoundments but instead comes from efficiency improvements and assumptions of a wetter climate by 2050.

Source: Hydro-Québec Deep Decarbonization Study, April 9, 2018,
Deep Decarbonization in the Northeast United States and Expanded Coordination with Hydro-Québec (unsdsn.org)

The lowest cost source of energy would be upgrades to existing facilities

ENERGYZT

Appendix A: Assumptions

Recent estimates support a wind cost in the range of $60-$65/MWh (CAN$)

Cost of Onshore Wind in Quebec

> Suddenly, wind power fits into Quebec's green vision. The power that Apuiat's 50 wind turbines will provide will not cost the 7.2 cents per kilowatt hour it would have in 2018, Legault noted. Hydro-Québec will be paying only six cents per kWh, which is 17 per cent less.

Does wind energy cost Quebec taxpayers more?

In Europe and Ontario, wind energy is purchased at rates above 10 cents per kWh, making Quebec wind energy rates among the best in Canada.

At the current rate of 6.5 cents per kWh, wind energy actually costs less than some hydropower projects such as Chute/Rapide-des-cœurs (8 cents per kWh) and the La Romaine project (9 cents per kWh).

Sources: https://montrealgazette.com/news/quebec/legault-reverses-course-on-apuiat-wind-farm-project-calls-it-a-win-win-win#:~:text=Suddenly%2C%20wind%20power%20fits%20into,is%2017%20per%20cent%20less., https://www.aqper.com/en/does-wind-energy-cost-quebec-taxpayers-more-4

Despite declining wind costs, Quebec is still paying a minimum $60/MWh (CAN$)

Appendix A: Assumptions

Quebec's LCOE for wind is estimated between $52/MWh to $86/MWh (CAN$)

Levelized Cost of Electricity for Wind in Canada (CAN$2018)

Table 3.21: Wind Power LCOE Assessment Results

		Levelized Cost of Electricity (cents/kWh)		
Province	**Number of Sites**	**Average**	**Minimum**	**Maximum**
Onshore Wind				
AB	75	5.2	4.4	6.2
BC	35	7.0	5.5	10.2
MB	12	5.9	5.3	6.6
NB	11	6.3	5.5	7.7
NL	8	5.6	5.2	6.2
NS	13	5.9	4.8	7.0
ON	83	6.1	5.2	9.9
PE	6	5.8	5.4	6.4
QC	81	6.3	5.2	8.6
SK	20	5.1	4.5	5.8
Offshore Wind				
NB	1	8.3	7.7	8.9
NS	2	8.9	8.3	9.5

Sources: Canada Energy Research Institute, https://ceri.ca/assets/files/Study_168_Full_Report.pdf

The model assumes an average price of CAN$63/MWh for any new wind built

Appendix A: Assumptions

The U.S. EIA estimates 2024 transmission costs at around $3/MWh (CAN$)

Levelized Cost of Electricity for Resources Entering Service in 2024 (US $2021)

Table A1b. Estimated unweighted levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) for new resources entering service in 2024 (2021 dollars per megawatthour)

Plant type	Capacity factor (percent)	Levelized capital cost	Levelized fixed O&M[a]	Levelized variable cost	Levelized transmis-sion cost	Total system LCOE or LCOS	Levelized tax credit[b]	Total LCOE or LCOS including tax credit
Dispatchable technologies								
Combined cycle	87%	$8.03	$1.68	$26.07	$1.03	$36.81	*NA*	$36.81
Resource-constrained technologies								
Wind, onshore	41%	$27.79	$7.65	$0.00	$2.36	$37.80	-$8.77	$29.03
Solar, standalone[c]	29%	$26.56	$6.34	$0.00	$3.16	$36.07	-$6.91	$29.16
Solar, hybrid[c,d]	28%	$35.57	$13.85	$0.00	$3.26	$52.68	-$9.25	$43.43
Capacity resource technologies								
Combustion turbine	10%	$47.70	$8.37	$42.41	$8.94	$107.42	*NA*	$107.42
Battery storage	10%	$63.85	$29.64	$29.39	$9.09	$131.98	*NA*	$131.98

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2022*

Sources: U.S. EIA, Levelized Cost of Electricity (2021), https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

The model includes a CAN$3.13/MWh transmission cost on all new builds

Appendix A: Assumptions

Transmission costs are further supported by previous HQ estimates

Transmission Cost Assumptions
(US $2005)

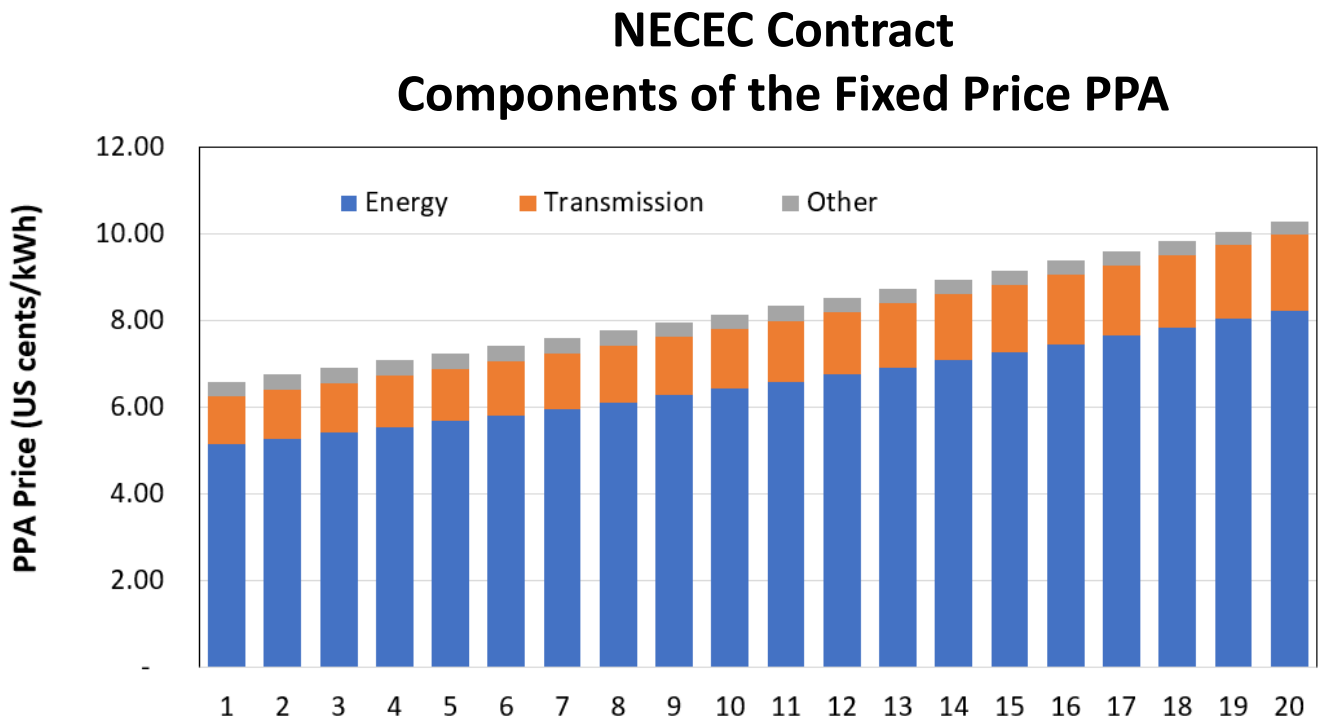
Cost Category	Cost	Unit
Base Transmission Cost	2,170	$/MW-mile
Grid Connection Cost	103	$/kW
Connect to: Substation	23.1	$/kW
Connect to: Load Center	23.1	$/kW
Connect to: Trans. Line	35.6	$/kW

Sources: Hydro-Quebec Deep Decarbonization Study. April 9, 2018.
https://irp-cdn.multiscreensite.com/be6d1d56/files/uploaded/2018.04.05-Northeast-Deep-Decarbonization-Pathways-Study-Final.pdf

When accounting for inflation, HQ's estimates align with recent projections

Appendix A: Assumptions

Massachusetts awarded a long-term contract to Hydro-Québec via NECEC



	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
NOMINAL																					
Total	**8.32**	**6.60**	**6.76**	**6.92**	**7.08**	**7.25**	**7.42**	**7.60**	**7.78**	**7.96**	**8.15**	**8.34**	**8.54**	**8.74**	**8.95**	**9.16**	**9.38**	**9.60**	**9.83**	**10.06**	**10.30**
Energy	6.58	5.15	5.28	5.41	5.55	5.69	5.83	5.97	6.12	6.28	6.43	6.60	6.76	6.93	7.10	7.28	7.46	7.65	7.84	8.04	8.24
Transmission	1.40	1.10	1.13	1.16	1.18	1.21	1.24	1.28	1.31	1.34	1.37	1.41	1.44	1.48	1.52	1.55	1.59	1.63	1.67	1.72	1.75
Other	0.34	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.32	0.32	0.31	0.31	0.31

HQ priced its energy at US$51.5 to $82.4 /MWh in year 20, a 2.5% escalation rate

ENERGYZT

Appendix A: Assumptions

New York agreed to pay US$97.75 / MWh - $176.36 / MWh for delivered energy

NYSERDA Power Purchase Agreements

The Tier 4 program procures both renewable energy and new transmission capacity and has been set up with an index renewable energy credit, or REC, structure to "help cushion customers against spikes in energy prices so when electricity prices rise the Tier 4 program costs go down," NYSERDA said.

With an expected average Tier 4 REC cost of $28.29/MWh for both projects, once the projects enter operation, the average bill impact for customers will be approximately 2%, or just over $2 per month, according to NYSERDA.

The Index Tier 4 REC strike price for each month in all years of the 25-year Clear Path contract is $129.75/MWh.

The Index Tier 4 REC strike price for each month in the first year of the CHPE contract is $97.50/Tier 4 REC which increases to $176.36/Tier 4 REC in the 25th year of the contract.

Sources: https://www.nyserda.ny.gov/About/Newsroom/2021-Announcements/2021-11-30-Clean-Path-NY-Champlain-Hudson-Power-Express-Renewable-Energy, https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/113021-contracts-approved-for-transmission-lines-to-bring-renewable-power-into-new-york-city

HQ energy supply costs are assumed to be the same as with the NECEC contract

Appendix A: Assumptions

Existing contractual commitments are added to demand projections

Contractual Energy Obligations

No.	Counterparty	Start Date	End Date	Type	TWh/year	Max MW
1	Ontario	2017	2023	Fixed	2.0	N/A
2	Cornwall	2000 & 2008	2030	Fixed	0.6	145
3	New Brunswick	2020	2040	Variable	4.5**	N/A
4	Vermont	2010	2038	Fixed	1.3	225

Potential Additions

5	NECEC (New England)	1/1/2024	12/31/2044	Firm Energy	9.45	1,200
6	CHPE (New York)	1/1/2027	12/31/2047	Firm Energy	8.3	1,100

*Load starting and projections do not account for losses that need to be generated., which are applied to supply resources and increase energy needs by 5.5% to 7.5%

**The contract does not provide for maximum annual deliveries. The volume of actual deliveries during the year 2020 is included only for reference

The load forecasts in these scenarios drive how much excess energy is available

Appendix A: Assumptions

Electric Vehicle load projections are held constant across all scenarios

Quebec 2030 Electric Vehicle Goals

Québec is leading the electric vehicle transition in Canada: it is home to more than 45% of Canada's electric vehicles, but only 23% of Canada's overall car fleet. The province passed the mark of 100,000 electric vehicles on its roads in April 2021. In its 2030 Plan for a Green Economy, published in 2020, Québec set a goal of having 1.5 million light-duty electric vehicles on its roads in 2030, which would represent about 30% of the light-duty fleet. To achieve this target, Québec has implemented many measures to spur electric vehicle uptake including offering financial incentives, establishing charging infrastructure deployment programs, creating electric vehicle consumer awareness initiatives, and setting a 2035 government target of ending sales of new fossil fuel passenger cars and light commercial vehicles. The Government of Canada also requires that all new light-duty cars and passenger trucks be zero-emission by 2035, accelerating Canada's previous goal of 100% sales by 2040. Québec's pursuit of transportation electrification is part of a larger strategy to promote climate resiliency and energy savings through increased use of domestic clean energy; indeed, more than 99.7% of Québec's electricity is produced from renewable sources.

Source: IRS, https://theicct.org/publication/lvs-ci-quebec-can-en-feb22/#:~:text=The%20province%20passed%20the%20mark,of%20the%20light%2Dduty%20fleet .

Quebec's EV policies are assumed to be in line with the CER – Evolving scenario