CANADIAN INSTITUTE FOR CLIMATE CHOICES

Improving integration and coordination of provincially-managed electricity systems in Canada

By Pierre-Olivier Pineau,
Chair in Energy Sector Management
HEC Montréal

Executive summary

The diversity of electricity sectors across Canada is manifold. On the surface, prices range from 7 to 16 ¢/kWh, and average consumption more than doubles from one province to another. But deeper differences result in almost disconnected markets. Market structures widely vary in vertical integration level, in ownership (from public to private), and in competition level in generation and retail. While cost-of-service regulation (in transmission and distribution) and tariff design are mostly similar in all provinces, each one has its own regulatory body that, by mandate, ignores what is going on in other provinces. Such a landscape creates uneven and self-centered provincial electricity markets that are not designed to collaborate and, consequently, are poorly positioned to support an efficient deep decarbonization of the economy.

Addressing this situation opens up three key opportunities: economic efficiency gains, the potential to integrate renewable energy, and improved regulation to support innovation. These opportunities can be seized through a greater collaboration among provinces, to work towards a more integrated electricity sector. Such integration would foster more trade, which will be even more beneficial when larger capacities of intermittent renewable energy are connected to the network. Hydro power reservoirs from British Columbia, Manitoba, Quebec and Newfoundland and Labrador could store excess wind and solar generation from other provinces when supply outstrips demand, if the adequate infrastructure, regulation, and market incentives were put in place.

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Such collaboration requires overcoming different challenges: perceived provincial roles, shortcomings in governance, a heterogenous set of players, vested interests, energy security concerns, and, lastly, traditional self-centered regulation. Various strategies can induce such market integration. The following four are discussed: (1) enhancement of bilateral provincial projects through renewed federal support; (2) a bottom-up movement to provincial convergence, following a Nordic approach to collaboration; (3) a negotiated free trade agreement in electricity, under the already established Canadian Free Trade Agreement, capitalizing on the existing "Regulatory Reconciliation and Cooperation" process; and finally (4) a federally led, healthcare-type process where key principles would be imposed on provinces to build the more integrated power system of tomorrow.

None of these strategies is easy, as will appear obvious to anyone. However, decarbonization will be more difficult and expensive if it cannot count on a more efficient power system, given the key role electricity will have to play in a carbon-neutral future. It is therefore in Canada's best interest to seek more collaboration in electricity. Failing to do so will only delay reaching Canada's climate goals.

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Introduction

The Canadian constitution delegates to provinces the right to organize their electricity sector.[1] This, combined with variations in provincial endowments of natural resources, has resulted in very different power sectors across Canada. Such diversity in provincial power sector regulation creates economic inefficiencies, by limiting trade, protecting markets, and inhibiting joint planning. In Canada's urgent decarbonization context, this lack of collaboration in provincial electricity markets is even more concerning: it slows down the progress towards a net zero society and increases its costs. Greater integration within the Canadian electricity patchwork would create a better decarbonization environment.

This white paper provides, in section 1, an overview of the regulatory and market landscape of Canada's electricity sector or, more precisely, of Canadian provinces' electricity sectors. Territories are not covered in this white paper due to space limitations and because their challenges are very different from the ones faced by provinces.[2] In section 2, key arguments from previous studies on the benefits of power sector integration are presented, along with the important challenges that will need to be overcome in Canada to achieve a greater degree of collaboration in electricity. Finally, section 3 identifies possible strategies that could be used to make progress towards this goal.

1. Current landscape: diversity in provincial electricity markets

Key differences in Canadian provinces' electricity sectors

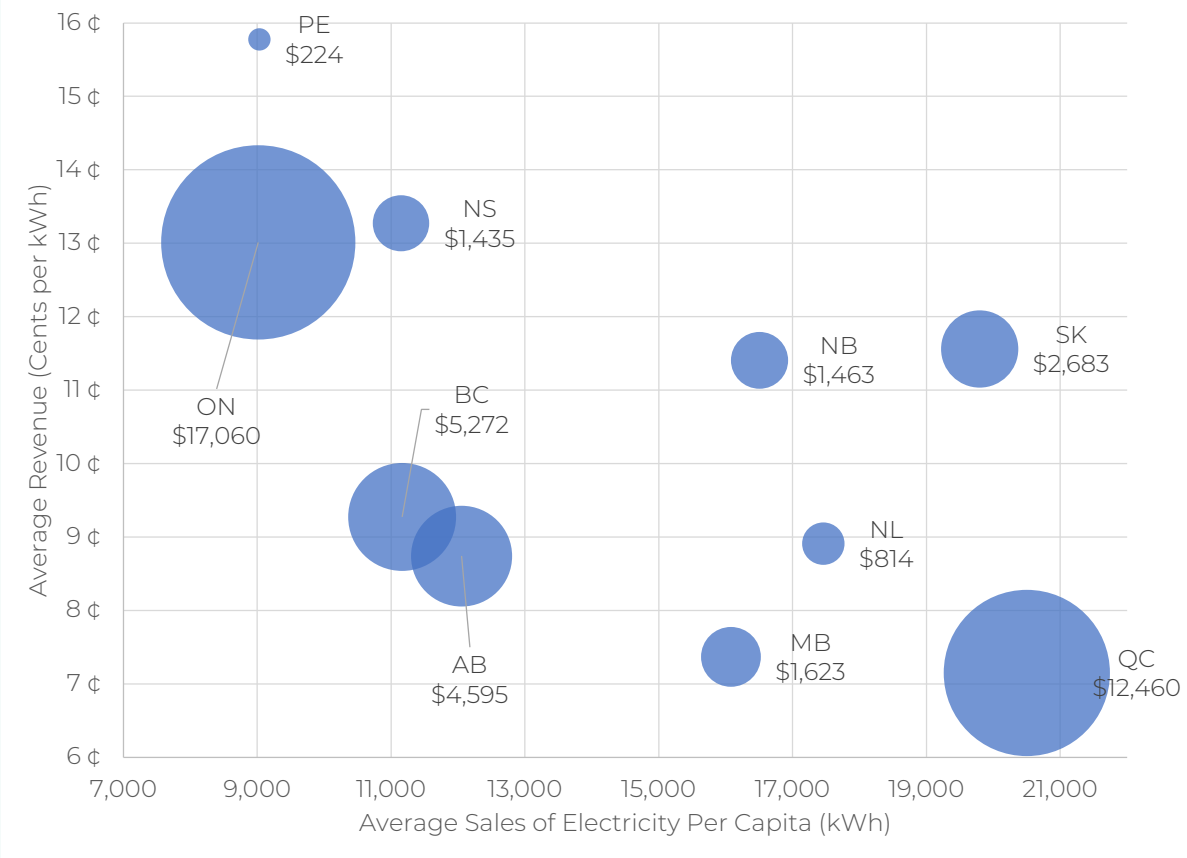
Average prices across the ten Canadian provinces ranged from 7 cents per kilowatt-hour (¢/kWh) to close to 16¢/kWh in 2019, as illustrated in Figure 1. These differences in average electricity prices contribute to similar variations in per capita consumption levels[3]: while Prince Edward Island (P.E.I.) and Ontario use only about 9,000 kWh per capita, due a combination of higher prices, natural gas heating, and warmer climates, Quebec leads the country in electricity consumption per capita, with more than 20,000 kWh. This high figure is explained by the availability of low-cost electricity, which feeds electricity-intensive industries (such as aluminum) and electric heating. Between these extremes, the diverse contexts of each province lead to different consumption levels, which vary even more within subsectors (see appendix).

The combination of different price and consumption levels and different population sizes, results in electricity sectors of very diverse sizes across the country, when measured through the value of electricity sales.[4] Ontario has the largest electricity sector, with sales totalling more than $17 billion, followed by Quebec ($12 billion). British Columbia (B.C.) and Alberta have electricity sectors of about the same size (around $5 billion). All other provinces are in the range $1.4 to $2.6 billion, except P.E.I. and Newfoundland and Labrador, which have much smaller sectors due to their small population.

1. See article 92A(1) of the Constitution (Government of Canada, 2021).
2. For more information on territorial electricity markets, see Senate of Canada (2015) and CER (2018).
3. Total industrial, commercial, and residential sales divided by the population.
4. Average sales multiplied by average price, directly taken from Statistics Canada (2021a).

Figure 1

Provincial average electricity sales per capita and price per kWh with total value of electricity (in millions of $), 2019 (Statistics Canada, 2021a and 2021c)

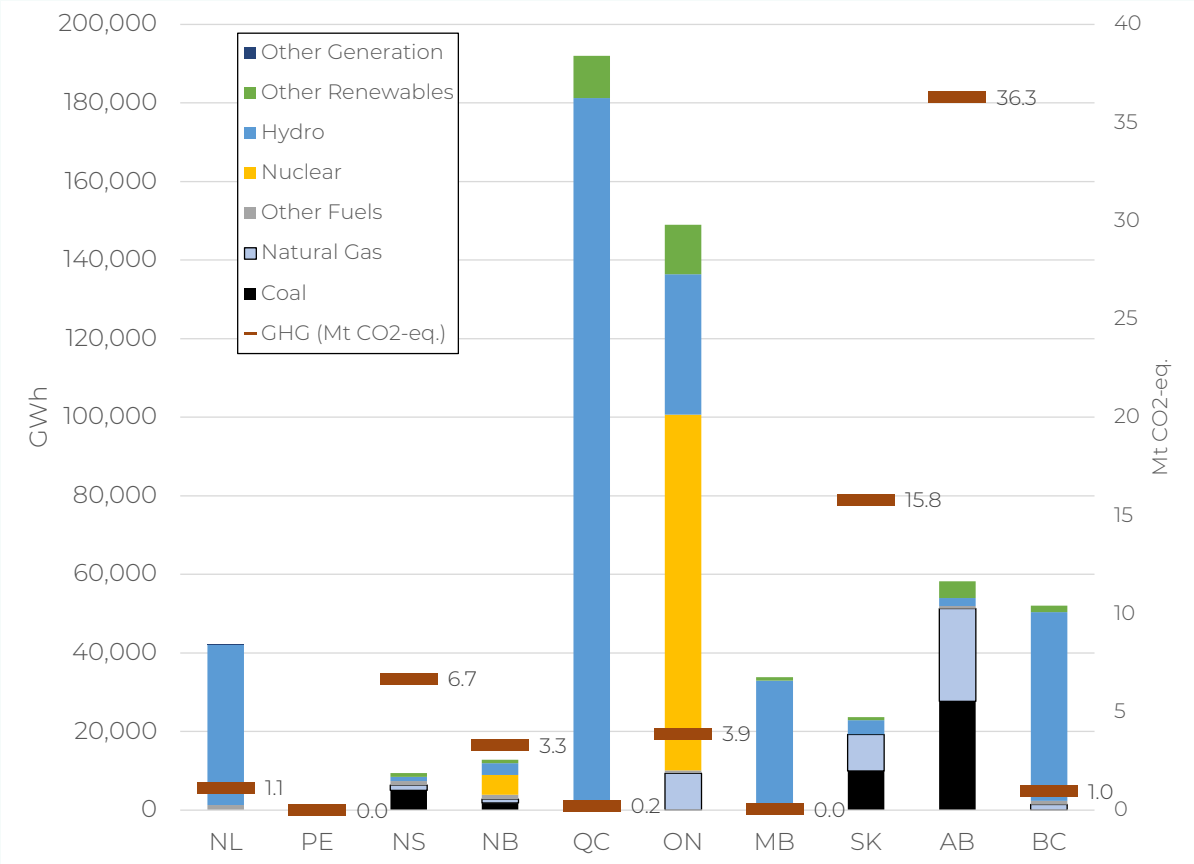


The generation mix is a key element to understanding the Canadian electricity patchwork. Figure 2 shows the electricity generated in each province in 2019, in gigawatt-hours (GWh). It's clearly visible that hydro power dominates in four provinces: B.C., Manitoba, Quebec, and Newfoundland and Labrador. Their geography allowed these provinces to build very competitive hydro power plants, which was not possible to the same extent in other provinces. Ontario and New Brunswick therefore rely on more diversified generation mixes, centered around nuclear and hydro, with natural gas and wind complementing generation in Ontario, and coal and other fuels making up the balance in New Brunswick. Alberta, Saskatchewan, and Nova Scotia, endowed with much more limited hydro power potential, rely mostly on fossil fuels (coal and natural gas), with some emerging wind generation.

Unsurprisingly, greenhouse gas (GHG) emissions from the power sector are the highest in the three provinces relying on coal and natural gas (Alberta, Saskatchewan, and Nova Scotia), with a total of almost 60 Mt of GHG emissions. This represents about 10 per cent of Canada's total GHG emissions (ECCC, 2021). Emissions are also non-negligible in Ontario and New Brunswick (above 3 Mt each). Even large hydro power provinces such as B.C. and Newfoundland and Labrador have emissions of around 1 Mt in their electricity sectors, illustrating the need for many provinces to make progress.

Figure 2

Provincial power generation by source and GHG emissions from the power sector, 2019 (ECCC, 2021)



These important differences in outcomes (price, consumption level, generation mix, and GHG emissions) are the most visible ones between markets. However, the underlying market structure and institutions of the provincial electricity sectors are also very diverse.

Market structure

Electricity markets can differ in many ways, but three key dimensions can summarize most of their differences:

- **VERTICAL INTEGRATION:** the extent to which the same organizations are involved in the generation, transmission, system operations, distribution, and retail activities of the sector.
- **OWNERSHIP:** from public (municipal, provincial) to private (investor-owned), with cooperative structures in between.
- **LEVEL OF COMPETITION:** generation and retail activities can be opened to competition or exclusive to certain companies, usually under some regulatory oversight.

Canadian provincial electricity markets can be grouped in three categories based on these dimensions. Figure 3 provides a visualization of this characterization of provincial electricity markets.

1. ***Vertically integrated Crown corporation with little competition.*** This is the most common market structure, found in B.C., Saskatchewan, Manitoba, Quebec, New Brunswick, and Newfoundland and Labrador. The provincial government owns the dominant electricity company (a Crown corporation), which is the main player in charge of generation, transmission, system operation, distribution, and retail. There can however be some other players, such as independent power producers (IPPs) and municipal, cooperative, or private distribution companies, supplying electricity in some regions of these provinces. Competition occurs in the wholesale market through long-term contracts between IPPs and the distribution division of the Crown corporation. The retail market is not open to competition, so customers' only choice is the regulated tariff offered by the distributor, under the oversight of the provincial regulator.

2. ***Vertically integrated private company with little competition.*** This is the situation in Nova Scotia and, to some extent, in P.E.I. In Nova Scotia, a single investor-owned company is responsible for the electricity sector of the province, with some supply contracts from IPPs and generators outside of the province. In P.E.I., a small vertically integrated, investor-owned company supplies electricity to most customers. Most of the electricity used in P.E.I. comes from outside the province, but generation on the island (mostly wind) is shared between IPPs and a relatively new provincially owned corporation (PEI Energy).

3. ***Unbundled electricity sector with open wholesale market and retail competition.*** Alberta and Ontario reformed their electricity sectors in 1996 and 2002, respectively (see Pineau, 2013), introducing an open, competitive, organized wholesale market providing an hourly price signal. The generation activities are carried on by investor-owned and municipally owned companies, as well as a Crown corporation in the case of Ontario. While Alberta mostly remains committed to the competitive aspects of its wholesale market, Ontario has reintroduced financial contracts hedging almost all generators from the market price. In Alberta and Ontario, transmission assets are mostly owned by investor-owned companies, earning a profit based on the regulated transmission tariffs of the province. System operations are under the control of a non-profit organization set up by the province: the Independent Electricity System Operator (IESO) in Ontario and the Alberta Electric System Operator (AESO). The IESO also has responsibilities in planning, conservation, and marketplace design, responsibilities which are usually not assumed by system operators. Distribution is mostly under the control of municipal companies in both Alberta and Ontario, offering a regulated retail option that competitive retailers can challenge in an open retail market.

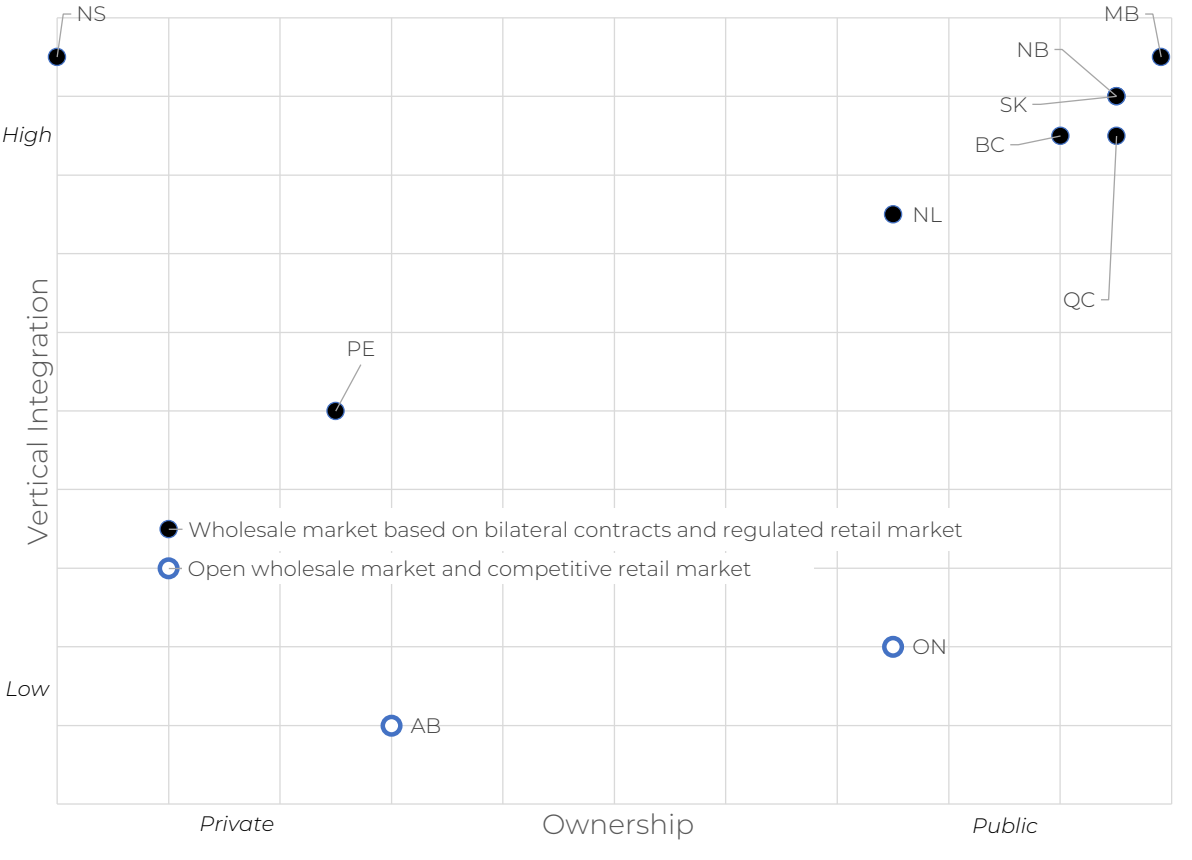
As illustrated in Figure 3, almost all types of electricity market structures exist in Canada, from highly vertically integrated to highly unbundled and from entirely private to dominantly public. The most common market structure is the vertically integrated Crown corporation with little competition, in the upper-right corner of Figure 3. In most provinces with this structure, the dominant generation source is hydro power. Only in Saskatchewan and New Brunswick do other generation sources play

an important role (see Figure 2). In Ontario and Alberta, while the level of vertical integration is very low (slightly higher in Ontario due to the more integrated structure of the transmission company in the distribution sector), public ownership remains significant. In Alberta it is through municipal companies, while in Ontario it is through both provincial and municipal companies.

Figure 3

Visualization of provincial electricity market structures along the ownership and vertical integration dimensions

(Author's own estimate based on information in Table 1)



Each province has its unique features, own regulation, and, in many cases, a dominant company owned by the provincial government. These companies are therefore focused on the province's needs and priorities and have little incentive to think outside of the regulatory framework they have been given. The significant government ownership in provincial electricity sectors also adds a layer of complexity in the orientations that these companies can take, as they don't always have the independence to follow the best strategies, from an electricity perspective, but can be influenced by other priorities, such as regional development, economic support for industries, social role, etc. On the other hand, in the future this provincial ownership could help to align these companies to the societal decarbonization goals if governments set up energy transition plans requiring changes in the electricity sector.

Table 1

Key provincial institutions and companies

	Regulator	System Operator	Generation	Transmission	Distribution	Retail	Source
NL	Newfoundland & Labrador Board of Commissioners of Public Utilities		**NL Hydro (Nalcor)** Newfoundland Power 3 IPPs	**NL Hydro** Newfoundland Power	**NL Hydro** Newfoundland Power	—	NL Hydro (2021) Government of Newfoundland and Labrador (2021)
PE	Island Regulatory and Appeals Commission		**PEI Energy Corporation**, Engie, **City of Summerside**	Maritime Electric **PEI Energy Corporation**	Maritime Electric	—	Government of PEI (2021) Maritime Electric (2021) PEI Energy Corp. (2021)
NS	Nova Scotia Utility and Review Board		NS Power 2 wind IPPs	NS Power	NS Power	—	Emera (2021)
NB	New Brunswick Energy and Utilities Board		**NB Power** Power Purchase Agreements (PPAs): 4 wind, 4 biomass, 2 hydro, 1 natural gas	**NB Power**	**NB Power**	—	NB Power (2020)
QC	Régie de l'énergie du Québec		**Hydro-Québec** 39 wind contracts 23 biomass contracts 46 hydro power producers	**Hydro-Québec**	**Hydro-Québec** **Municipally owned electric utilities (9)** **Cooperative (1)**	—	Hydro-Québec (2020) MERN (2019) AREQ (2014)
ON	Ontario Energy Board	Independent Electricity System Operator (IESO)	**Ontario Power Generation** Total of 228 licensed electricity generators	Hydro One and 9 licensed electricity transmitters	Hydro One **Municipally owned electric utilities** Total of 68 licensed electricity distributors	Retailers (72)	OEB (2021a)
MB	Manitoba Public Utilities Board		**Manitoba Hydro** 2 IPPs	**Manitoba Hydro**	**Manitoba Hydro**	—	Manitoba Hydro (2020)
SK	Saskatchewan Rate Review Panel		**SaskPower** 11 IPPs	**SaskPower**	**SaskPower, Saskatoon Light & Power and Swift Current Electricity Services**	—	SaskPower (2020) Energyrates.ca (2021)
AB	Alberta Utilities Commission Alberta Market Surveillance Administrator	Alberta Electric System Operator (AESO)	TransAlta, Heartland Generation, Capital Power, **ENMAX**, Suncor > 40 IPPs	AltaLink, ATCO Electric, **ENMAX Power**, **EPCOR**, TransAlta	Investor-owned electric utilities (3) **Municipally owned electric utilities (6)** **Rural electrification associations (40)**	Retailers (47)	MSA (2021) AUC (2021) Utilities Consumer Advocate (2021a)
BC	British Columbia Utilities Commission		**BC Hydro** FortisBC 107 IPPs	**BC Hydro** FortisBC	**BC Hydro** FortisBC Municipally owned electric utilities (5)	—	Government of British Columbia (2021) BC Hydro (2021a)

IN BOLD: publicly owned company (cooperative, municipal, provincial)

Key institutions and players

Each province has its own electricity regulator, overseeing the transmission and distribution rates that remain regulated. This is true even in Alberta and Ontario, where some reforms have taken place to open generation and retail (both non-wire activities) to competition. These regulators operate according to their specific legal framework, defined by provincial laws.

The largest provincial Crown corporations (Hydro-Québec, Ontario Power Generation, BC Hydro, Manitoba Hydro, Nalcor, SaskPower, New Brunswick Power) are responsible for most of the Canadian electricity generation and own the largest share of generation, transmission, and distribution assets. Their main goal is to supply electricity for their province, and they also pay a dividend to their unique shareholder, their provincial government. In Manitoba, however, Manitoba Hydro cannot legally make a profit and therefore does not pay any dividend to the province (Government of Manitoba, 2021).

Table 1 synthetizes the set of institutions and players for the ten provinces. Publicly owned entities are in bold in the table, to highlight their importance and diversity. One investor-owned company has a significant presence in many provinces: Fortis. This company owns generation or distribution assets in B.C., Alberta, Ontario, P.E.I., and Newfoundland and Labrador (Fortis, 2021) and is the most pan-Canadian electricity player.

Regulation and tariffs

The transmission and distribution activities across Canada are regulated by provincial regulators under a cost-of-service methodology (Christian and Shipley, 2020). Each regulator sets a rate of return earned by companies, based on their allowed investments. This traditional cost-of-service regulation may not be the ideal approach for investment in transmission and distribution assets, as they tend to favour additional assets (over which a return is earned) at the expense of possible alternative approaches, such as energy efficiency or demand-side management, which are less straightforward to remunerate.

Investments in generation are not directly regulated (beyond the environmental regulation all projects must comply with), but supply contracts between generators and distributors are included in the bundled electricity rates that most Canadian customers pay. Only in Alberta and Ontario, where the retail segment of the electricity sector is open to competition, can customers opt for competitive retail energy contracts where the price they pay for their electricity is based on the market price, not on long-term contract prices between generators and distributors. However, regulated retail options are still available for customers in Alberta (Utilities Consumer Advocate, 2021b), as well as in Ontario (OEB, 2021b).

Costs from all activities required in the electricity sector (generation, transmission, system operations, distribution, and retail services) are recovered through the price customers pay. In most provinces, there is no cost breakdown to let customers know which activity costs what, because costs are all bundled in a single price. In Alberta and Ontario, where there is less vertical integration, the cost breakdown is easier to obtain and is reported in rates and bills. Table 2 illustrates the bundled and unbundled rates in the illustrative case of BC Hydro and ENMAX (Calgary). Only

these two examples are shown because the absence of rate structure variety across Canada makes it unnecessary to present more cases. However, see Bishop et al. (2020) for more details and an in-depth comparison of electricity rates and costs in Canada.

Tariffs are structured under three components:

1. **A fixed charge**, per day of service, irrespective of the amount of energy used and peak demand.
2. **An energy charge**, or volumetric charge, based on the amount of energy used in a given period (usually per month).
3. **A demand charge**, or power charge, based on the peak demand use (in kW or kVA[5]) during a given period, or based on a subscribed level of service.

All these three components can vary, or not, depending on the hour, day and season, depending on how the rate is defined. In practice, however, they are mostly constant across time, except in Ontario where time-of-use rates are the default. Regulators usually design rates for residential customers that have only a fixed charge and an energy charge. Rates for commercial and industrial customers usually have all three components, including a demand charge. Table 2 below illustrates these typical rates, using the cases of BC Hydro and ENMAX, in Calgary. Both the residential and medium commercial rates are shown, to illustrate how the different components are used. In the case of ENMAX, both the "regulated" and the "competitive" options are shown.

5. Kilowatt (kW) is the power and kilo-Volt-Ampere (kVA) is the apparent power used by a consumer. The relationship between the two is kW = kVA x power factor, where the power factor measures the efficiency of the electrical system, between 0 and 1 (Power Electric, 2021).

Table 2

Typical electricity rates, using B.C. and Alberta (Calgary) examples

	Fixed Charge	Energy Charge	Demand Charge
BC Hydro Residential Rate (BC Hydro, 2021b)	20.80¢/day	9.41¢/kWh (block 1) 14.10¢/kWh (block 2) Block 1: 22.1918 kWh/day Block 2: no limit	—
BC Hydro Medium General Service Rate (BC Hydro 2021c)	26.61¢/day	9.63¢/kWh Up to 550 MWh/year	$5.39/kW/month 35 to 150 kW
ENMAX (Calgary) Residential Regulated Rate Option (July 2021) ENMAX (2020, 2021a, 2021b)	22.01¢/day Administration Charge 60.49¢/day Distribution Service and Facilities Charge	**6.78¢/kWh** (June 2021) **Fluctuates monthly** 1.2168¢/kWh Distribution System Use Charge 3.7638¢/kWh Transmission Variable Charge	—
ENMAX (Calgary) Medium Commercial Regulated Rate Option Regulation (July 2021) ENMAX (2020, 2021a, 2021b)	19.75¢/day Administration Charge $7.58/day Distribution Service Charge	**6.78¢/kWh** (June 2021) **Fluctuates monthly** 0.902¢/kWh Transmission Variable Charge	5.147¢/kVA/day Distribution Facilities 4.691¢/kVA/day Distribution 25.63¢/kVA/day Transmission
Competitive rate (energy only) Similar for residential and business customers ENMAX (2021c, 2021d)	*Same as above*	*Same as above except for the* **energy rate (in bold above)** Fixed rates options 6.79¢/kWh 1-Year Fixed 6.69¢/kWh 3-Year Fixed 6.89¢/kWh 5-Year Fixed Floating rate option Index Electricity Rate + 1¢/kWh fee (business customers only)	*Same as above*

Opportunities from the current electricity landscape

The leadership of provinces in electricity have resulted in significant accomplishments that place Canada in a desirable position in international electricity sector comparisons: power supply in Canada is relatively cheap, abundant, and clean (IEA, 2020). However, the diversity across Canada, documented in this section, is far from optimal. It is consequently the source of many opportunities that Canada could exploit to better meet the decarbonization challenges facing this country.

These opportunities, arising from the current state of electricity sectors across Canada, can be summarized in three key categories:

1. **Improving economic efficiency**. Price differentials across provinces are a cause of economic inefficiencies: they contribute to overconsumption in provinces with lower prices and lead to more expensive choices in provinces with higher prices. If freer electricity trade was enabled across Canada, welfare gains would be obtained. Some economic efficiency gains could be achieved.

2. **Facilitating integration of renewables**. The integration of additional wind and solar generation capacity will require more options for balancing supply and demand. This would greatly benefit from additional interconnections, joint planning and operating bodies, and common-market incentives. The existing hydro power reservoirs in B.C., Manitoba, Quebec, and Newfoundland and Labrador offer important energy storage opportunities. However, they are currently difficult to exploit to facilitate renewable integration in neighbouring provinces, due to the absence of joint analysis.

3. **Supporting technological innovation and diffusion**. Distributed energy resources (DER, including solar panels and batteries), electric vehicles, vehicle-to-grid technology, and smart homes represent an important set of technological innovations. The deployment of these innovations is hindered by traditional cost-of-service regulation and existing rates, because they don't provide an adequate set of incentives to distributors and customers. The multiplicity of different rules and incentives across provinces also makes it harder to replicate good innovation. Regulatory changes and harmonization could create a better market environment to support technological innovation and diffusion.

In the next sections, we explore how more collaboration and integration across provincial electricity sectors could help in seizing these opportunities.

2. Harmonizing the landscape

The Canadian electricity landscape has been a patchwork for years. Calls for reforms, to achieve more collaboration and integration, have been made both from national and international groups. In this section, we present some of the literature on power sector integration, specific or not to Canada.

Previous studies on power sector integration

Since the early 2000s, many documents have presented the reasons for more integration in the electricity sector. The United Nations published many reports on the subject (for instance, see UNECA, 2004 and UN, 2006), and so have the World Bank (ESMAP, 2010), the World Energy Council (WEC, 2010), the Organization of American States (OAS, 2007), and even the Montreal-based Commission for Environmental Cooperation (CEC, 2002), a Canadian-U.S.-Mexican institution. The first recommendation of the International Energy Agency in its periodic review of the Canadian energy policy is that "the government of Canada should facilitate market integration" (IEA, 2016). More specifically, for electricity, the IEA's primary recommendation is that government of Canada should:

> ***Work with the provinces and the electricity industry to facilitate greater east-west interconnectivity between Canada's electricity networks and greater integration of Canada's electricity markets more generally.***

The key arguments for cooperation, and up to a full-sector integration, are similar to trade rationales: economic efficiency and economies of scale that can be achieved and generate greater wealth. Shared institutions harmonize rules and regulations, making it easier for economic actors (both producers and consumers) to access the best alternatives to meet their needs. For more details on these arguments, see Pineau (2013). Without such institutions, an Ottawa resident pays an on-peak (11 a.m. to 5 p.m.) price during the weekdays of 17 ¢/kWh (Hydro Ottawa, 2021), while Gatineau residents, just on the other side of the river, pays 6.16 ¢/kWh (Hydro-Québec, 2021). The price difference is not even justified by the environmental attributes of the electricity: the Quebec generation mix is arguably cleaner that the Ontario one (see Figure 2). It's hard to find another product or service for which there is such a large and systematic price difference. In a decarbonization context, integration and balancing demand and supply of intermittent sources such as wind and solar can also be greatly facilitated through enhanced transmission and access to hydro power reservoirs (NREL, 2021; Rodriguez Sarasty et al., 2021).

Different Canadian voices have also called for more integration, of some type, across the country: the Canadian Electricity Association (CEA, 2007; 2012) and the Canadian Academy of Engineering (CAE, 2009; 2012), while the Canadian Senate has raised questions on the level of preparedness of the electricity sector for decarbonization (Senate of Canada, 2010; 2017). Calls for regu-

latory modernization have also been made, most recently by the CEA (2021), to both upgrade the transmission network and renew the provincial regulatory frameworks, to be ready for the challenges of the "4 Ds": decarbonization, decentralization, digitalization, and democratization. Natural Resources Canada (NRCan) heavily favours such integration, notably through its support for the Atlantic Energy Gateway (see for instance Navigant, 2013) and more recently through the Regional Electricity Cooperation and Strategic Infrastructure (RECSI) Initiative, which has resulted in two studies: one for Western Canada (GE, 2018) and one for Atlantic Canada (Hatch, 2018). Current resources put in the "Atlantic Loop" initiative also illustrate the strong belief that more integration can result in beneficial outcomes (NRCan, 2020; 2021).

Challenges to overcome

Despite lasting economic and environmental rationales for more interprovincial collaboration and integration, little progress has been made. Provincial power sectors have not evolved closer to each other in the last 50 years. More collaboration across Canadian provinces in the electricity sector could happen by overcoming or bypassing a series of challenges. By identifying and understanding them, we are more likely to be able to find strategies to make progress. Here is a top-down list of these challenges:

1. **Constitutional separation of power fortifies provincial silos**. According to the Canadian constitution, provinces have jurisdiction over energy and natural resources within their borders. Revenues from these sectors go to the provincial government, and they often see federal action in these sectors as potential threats to their independence and powers. While constitutional changes are not on the agenda, it must be recognized that creating bridges between silos is not an attack on provincial powers, especially since these bridges can generate wealth, facilitate the penetration of renewable energy sources, and lead to more efficient consumption levels.

2. **Lack of governmental vision and shortcomings in governance maintain the status quo**. While each province has its own energy and environmental policy, no government has a clear vision, with a credible governance, to decarbonize its economy by 2050. The habit of relying on the private sector or on Crown corporations to develop the electricity sector, without maintaining a strong electricity policy expertise within the government or in research organizations, leaves government relatively clueless on how to approach the significant challenge of decarbonizing the power sector in order to help achieve a carbon-neutral economy. Because different decarbonization responsibilities fall under different ministries, agencies, and companies, integrated governance is clearly missing. This results in inertia, with little to no leadership to move beyond the status quo.

3. **Heterogenous market organizations and institutions create a cacophony of discourses**. Given the current landscape of very different electricity sectors across Canada and the absence of clearly successful provincial electricity reforms, no obvious leader or prominent voice can be identified. This lack of model to follow and the almost opposed organizational cultures, between centralized crown corporations, private firms operating in competitive environments and traditional regulators, create a setting with no common language and a very limited space for dialogue.

4. **Vested interests in electricity price differentials deepen inertia**. The significant price and consumption differences across provinces, as illustrated in Figure 1, create a situation where, on the one hand, consumers in lower-cost provinces fear higher prices (which could result from a more integrated market) and, on the other, producers in higher-cost provinces fear cheap imports. Both groups lobby their respective government to not change anything in the current landscape, to protect their low prices and market shares. These vested interests intersect with equity considerations ("low prices help lower-income households") and job considerations ("imports could cost well-paid jobs in the province"), which are sensitive issues for politicians. These vested interests in the status quo being strong, they often appear insurmountable for those aiming at longer-term benefits — such as decarbonization.

5. **Concerns around energy security and independence foster internally focused planning and perspectives**. The fear of depending on imports for something as essential as electricity also contributes to the status quo. The COVID-19 pandemic contributed to highlight some of the vulnerabilities when a society depends on international supply chains (for vaccines, medical equipment, food). Furthermore, cyberattacks, such as the one that shut down the Colonial Pipeline in May 2021 in the United States, can contribute to seeing additional interties as a potential problem. On the other hand, increased network interconnections can also improve reliability by allowing access to more sources and diversifying supply. The Texas power sector's near collapse in February 2021 was worsened by the isolated nature of the sector: neighbouring power systems could not supply electricity, given the limited interties. However, the notion of security and independence remain significant challenges, especially with the rapid development of DER. The combination of photovoltaic (PV) and small-scale storage options contributes to the idea that it's possible, and even desirable, to get rid of grids and central systems. Detailed studies show, however, that DER are not pure substitutes for central systems and that interregional exchanges can be extremely beneficial for renewable integration (NREL, 2021).

6. **Path dependency in institutions and tariffs favours replication over innovation**. Regulators across Canada are appointed by governments and must regulate in accordance with their legal framework. Such frameworks do not change quickly, and regulators have not developed a culture of innovation: they fulfill the mandate they are given, which is essentially to set the lowest rates according to cost-of-service principles. They are also not given the mandate to identify opportunities beyond their own borders. Regulators' risk management is very conservative by nature, because of their sensitivity to negative outcomes (e.g., power shortages, price increases). GHG emissions related to energy are outside of their energy mandate, so electrification and deep GHG reductions are clearly out of their scope. Achieving decarbonization at the lowest cost, with the required innovations in tariffs and technologies, implies some unprecedented changes that are at odds with the historical regulation approach across Canada.

Knowing these challenges does not make them easier to overcome. Such knowledge can, however, help thinking about strategies to address the many legitimate concerns linked to these challenges. In the next section, some strategies are identified to foster more collaboration among provinces in the electricity sector.

3. Four possible strategies for increased collaboration in electricity

There is no obvious or easy strategy to increase collaboration in electricity across Canada. But the same can be said about decarbonization: it's going to be extremely hard and will require some fundamental changes. Trying to achieve carbon neutrality without relying on a strong and modern grid would add to the complexity of the challenge. This is why it is important to contemplate how to better integrate power sectors across Canada: to minimize the cost of relying on a clean energy supply. The four strategies below present possible approaches.

Enhanced bilateral collaboration and revised internal regulation strategy

Many agreements and collaborations have already been taking place between provinces. The most one-sided is probably the Churchill Falls contract signed in 1969 between Quebec and Newfoundland and Labrador (Martin, 2006). This contract (ending in 2041) of about 30 TWh of annual exports from Labrador to Quebec at a very low price has an uneven allocation of benefits. But more recent agreements create more equal benefits for the parties involved. For instance, the 2015–2025 Capacity Sharing Agreement between Ontario and Quebec (see IESO, 2015) is a good example of collaboration. The two provinces exchange 500 MW of capacity when required during their summer peak (in Ontario) and winter peak (in Quebec). Since March 2021, the Birtle Transmission Project (a 230-kV transmission line between Manitoba and Saskatchewan) has allowed more hydro power to flow to Saskatchewan (SaskPower, 2016; Manitoba Hydro, 2021). This latter project was made possible through a $18.8 million federal contribution.

Such bilateral agreements could be further developed. This aligns with the current federal strategy, as deployed by NRCan through its Regional Electricity Cooperation and Strategic Infrastructure (RECSI) and Atlantic Loop initiatives, mentioned earlier in this white paper. If accompanied by internal provincial reforms to better respond to the three central issues (economic efficiency, technological innovation, and integration of renewables), then some progress could be made.

This strategy works around all the identified challenges by trying to develop projects one at a time. It avoids deeper reforms by convincing companies and provincial governments to work together on explicit initiatives (in most cases, a new transmission line). In the longer run, by working on joint projects, a new culture of collaboration could slowly emerge and lead to institutional changes.

Bottom-up collaborative strategy: a Nordic inspiration

A deeper and more ambitious strategy would be to break away from past approaches and follow the example of Nordic countries (Norway, Sweden, Finland and Denmark). These countries have followed the innovative Norwegian model, which reformed the electricity market to promote trade and transparency (Amundsen and Bergman, 2006). They now work under voluntary regional institutions to jointly deal with the issues they face. These non-governmental institutions are the Nordic Council and the Nordic Council of Ministers (https://www.norden.org), NordREG (Nordic

energy regulators, https://www.nordicenergyregulators.org/) and Nordic Energy Research (https://www.nordicenergy.org/).

The Nordic example is interesting because it was not promoted by a federal government or a supranational body (such as the European Union in Europe). Countries with their own constitutional powers over energy, exactly as Canadian provinces have, decided to reform their electricity sector in order to converge towards a common framework, with similar institutions and rules. Nothing could prevent Canadian provinces from following an analogous process, while accommodating the unique requirements created by the North American context.

Such a strategy would not have to be coast-to-coast and could be limited to a subgroup of provinces, such as the Atlantic ones or the Prairies. The smaller initial number of provinces could allow some "proof of concept" to be made, while other provinces could join in a second stage. Energy ministers from the participating provincial governments would have to create a working group overseeing the process, informed by technical and economic studies on the costs and benefits of such integration. The second challenge— government vision and governance — would have to be overcome to start the process. The complementarity of hydro, wind and solar resources would be at the center of the justification of such an integrated approach.

Free trade strategy

The Canadian Free Trade Agreement (CFTA), which replaced the Agreement on Internal Trade (1995–2017), could be a tool to open electricity markets and force more exchange. Currently, many exemptions are granted to provinces in the electricity sector, allowing them to structure and operate their electricity sector in a way that prevents producers and consumers from entering into contractual agreements with out-of-province entities, as in other markets. For instance, returning to the Ottawa-Gatineau example, a Gatineau customer could not resell electricity to an Ottawa customer, nor could this Ottawa customer sign a contract with Hydro-Québec. Through such a free trade strategy, a negotiated harmonization of rules could follow, and a more open and competitive market could emerge. Such strategy has been studied by D'Onofrio (2016).

This strategy would require a lot of political capital to convince provinces to agree on something they have been considering since at least 1995. Indeed, from the start of the Agreement on Internal Trade, the energy sector was considered as a sector to include in the trade agreement, but no consensus was found. Premiers of provinces would need to be convinced by economic and environmental considerations and be able to communicate to their voters that collective gains are worth the restructuring effort. While this approach is unlikely, the CFTA has an already-established "Regulatory Reconciliation and Cooperation" process that could offer a framework for work on the convergence of provincial power sectors.

A healthcare-type strategy

The federal government could push for harmonization across provinces by following a strategy inspired by the one in healthcare: common criteria on portability, accessibility, universality, comprehensiveness, and public administration (Government of Canada, 2019). The federal

government could tie funding to the implementation of these principles, which would result in different, but equivalent, systems. The common features of these provincial markets would lead to the required harmonization, allowing more efficiency, integration of renewables, and technological innovation to penetrate the electricity sector.

Working on these shared principles could be seen as more promising than working on the antagonist approach frequently associated with free trade. It would also have the benefit of building on a made-in-Canada approach to healthcare, which has been mostly positive for the country.

Conclusion

Canada's electricity sectors are an asset for its transition towards carbon neutrality, given their initial low-carbon content. But their diversity and the lack of collaboration between provinces results in economic inefficiencies, an absence of joint planning, and missed opportunities to integrate renewables. Furthermore, provincially based cost-of-service regulation in transmission and distribution does not create the adequate framework for an optimal modernization of the grid, where distributed energy resources (DER) would smartly interact with producers and consumers connected to the grid. The various incentives and regulatory burden in each province prevent a strong and coherent electric landscape to emerge, one that would be extremely useful – if not essential – to support Canada's progress towards a carbon neutral society.

More collaboration is therefore required across provinces, to start an integration process that will facilitate Canada's decarbonization. Despite significant challenges resulting from the historical development of the electricity sector in each province, strategies can be developed to work towards more integration: enhanced bilateral collaboration supported by the federal government, a bottom-up strategy à la Nordic countries, a negotiated free trade framework in electricity built within the Canadian Free Trade Agreement, or a healthcare-type pan-Canadian approach based on shared principles.

While there is no easy path towards electricity market integration, the decarbonization road will only be made harder if Canada preserves its 20th century electricity institutions. Efficient reduction in GHG emissions will require a strong power grid, one that cannot rest on the diversified landscape we currently observe across Canada.

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Appendix

Per capita electricity consumption by sub-sector in Canadian provinces in 2019, kilowatt-hour (Statistics Canada, 2021b and 2021c)

As shown through the table below, if Quebec led electricity per capita consumption in 2019 (close to 24,000 kWh, versus 9,579 kWh in Ontario, the lowest), it's largely because of its industrial consumption (10,666 kWh per capita, versus 1,644 kWh in P.E.I., the lowest) and residential consumption (8,321 kWh per capita, versus 1,617 kWh in P.E.I., again the lowest). Commercial and institutional consumption is mostly similar across the country (between 3,000 and 5,000 kWh per capita). Per capita agriculture consumption levels are very high in Manitoba, Saskatchewan, and P.E.I., largely due to the relative importance of their farming sectors. High per capita electricity consumption in transport in Saskatchewan and Manitoba (respectively 2,275 and 1,014 kWh) would require further investigation before we can comment on it.

	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC
Industrial	6,972	1,644	2,261	6,151	10,666	2,677	4,063	8,685	6,241	5,178
Transport	5	-	-	-	56	37	1,014	2,275	452	123
Agriculture	65	2,648	75	102	252	181	635	1,135	461	189
Residential	8,104	1,617	4,889	7,367	8,321	3,021	6,420	3,038	2,307	3,904
Commercial & institutional	4,855	4,685	3,699	4,030	4,673	3,663	4,114	5,038	4,064	3,387
Total	20,001	10,594	10,925	17,649	23,969	9,579	16,245	20,172	13,524	12,781